```matlab
disp('Program Plasma6.m');
%; plasma6.m - program to compute current required for fusion in bottle
%;
%; compute the ring equation
 ;    - int(dB)  = int(i ds x r / r^2)
 ;
%;    - Therefore
%;
%;    - int(dBx) = int(dsy*rz - ry*dsz/ r^2)
%;    - int(dBy) = int(dsx*rz - rx*dsz/ r^2)
%;    - int(dBz) = int(dsx*ry - rx*dsy/ r^2)
%;    - convert each of these into an f(x,y,z,r1,px1,py1,pz1,th1,th2)
%;    - polynomial matrix: each term ^4 ^3 ^2 ^1 - 0.5 7.0 35.0 150.0
%;    - B vector: i ds x r/ r^2 for 64 different points for each 3 var.
%;    - int(dBx,dBy,dBz) = (expressed in terms of vectors)
fid = fopen('g:/draw1/plasma6.txt','w');
fprintf(fid,'\nPlasma6.m - Output\n');
syms x1 y1 z1 x0 y0 z0 th1 r1 atmp;
syms dBx dBy dBz Bx By Bz B u0;
u0 = 1/(10^7);
x1 = r1*cos(th1) + x0;
y1 = r1*sin(th1) + y0;
z1 = z0;
syms x2 y2 z2 ro1 th2 the1;
ro1 = sqrt((x1 - x0)^2 + (y1 - y0)^2 + (z1 - z0)^2);
th2 = atan((y1 - y0)/(x1 - x0));
the1 = acos((z1 - z0)/(th2));
x2 = ro1*cos(th2)*sin(the1);
y2 = ro1*sin(th2)*sin(the1);
z2 = ro1*cos(the1);
syms r11 r1x r1y r1z;
syms px1 py1 pz1;
 1x = (px1 - x2);
 1y = (py1 - y2);
r1z = (pz1 - z2);
r11 = sqrt(r1x^2 + r1y^2 + r1z^2);
syms coefr1 coefr2 coefr3 coefr4 coefr5 ar1 br1 r11ap;
r1 = 1.0;
th1 = 0.0;
px1 = 2.0;
py1 = 0.0;
pz1 = 0.0;
ar1 = [r1x^4 r1x^3 r1x^2 r1x^1;];
br1 = [eval(r11);];
px1 = 8;
ar1 = [ar1; r1x^4 r1x^3 r1x^2 r1x^1;];
br1 = [br1; eval(r11);];
px1 = 16;
ar1 = [ar1; r1x^4 r1x^3 r1x^2 r1x^1;];
br1 = [br1; eval(r11);];
px1 = 48;
ar1 = [ar1; r1x^4 r1x^3 r1x^2 r1x^1;];
br1 = [br1; eval(r11);];
coefr1 = pinv(eval(ar1))*br1;
disp('coefr1...');
px1 = 2.0;
py1 = 0.0;
pz1 = 0.0;
r1 = 1.0;
th1 = 3.14159/2;
ar1 = [th1^4 th1^3 th1^2 th1^1;];
br1 = [eval(r11) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;];
th1 = 3.14159;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; eval(r11) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^
1;];
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```
th1 = 3*3.14159/2;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; eval(r11) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^
1;];
th1 = 2*3.14159;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; eval(r11) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^
1;];
coefr2 = pinv(ar1)*real(br1);
disp('coefr2...');
r1 = 1.0;
py1 = 0.0;
pz1 = 0.0;
th1 = 0.0;
px1 = 2;
ar1 = [px1^4 px1^3 px1^2 px1^1;];
atmp = eval(r11) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
br1 = [atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;];
px1 = 8;
ar1 = [ar1; px1^4 px1^3 px1^2 px1^1;];
atmp = eval(r11) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
br1 = [br1; atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^
1;];
px1 = 18;
ar1 = [ar1; px1^4 px1^3 px1^2 px1^1;];
atmp = eval(r11) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
br1 = [br1; atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^
1;];
px1 = 48;
ar1 = [ar1; px1^4 px1^3 px1^2 px1^1;];
atmp = eval(r11) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
br1 = [br1; atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^
;];
oefr3 = pinv(ar1)*real(br1);
disp('coefr3...');
r1 = 1.0;
px1 = 0.0;
pz1 = 0.0;
th1 = 0.0;
py1 = 2;
ar1 = [py1^4 py1^3 py1^2 py1^1;];
atmp = eval(r11) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;];
py1 = 8;
ar1 = [ar1; py1^4 py1^3 py1^2 py1^1;];
atmp = eval(r11) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [br1; atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^
1;];
py1 = 18;
ar1 = [ar1; py1^4 py1^3 py1^2 py1^1;];
atmp = eval(r11) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [br1; atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^
1;];
py1 = 48;
ar1 = [ar1; py1^4 py1^3 py1^2 py1^1;];
atmp = eval(r11) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [br1; atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^
;];
coefr4 = pinv(ar1)*real(br1);
disp('coefr4...');
px1 = 0.0;
py1 = 0.0;
```

```
th1 = 0.0;
r1 = 1.0;
pz1 = 2;
ar1 = [pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = eval(r11) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^1;];
pz1 = 8;
ar1 = [ar1; pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = eval(r11) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [br1; atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^
1;];
pz1 = 32;
ar1 = [ar1; pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = eval(r11) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [br1; atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^
1;];
pz1 = 48;
ar1 = [ar1; pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = eval(r11) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [br1; atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^
1;];
coefr5 = pinv(ar1)*real(br1);
disp('coefr5...');
syms r1 th1 px1 py1 pz1;
r11ap = coefr1(1)*r1^4 + coefr1(2)*r1^3 + coefr1(3)*r1^2 + coefr1(4)*r1^1;
r11ap = r11ap + coefr2(1)*th1^4 + coefr2(2)*th1^3 + coefr2(3)*th1^2 + coefr2(4)*th1^1;
r11ap = r11ap + coefr3(1)*px1^4 + coefr3(2)*px1^3 + coefr3(3)*px1^2 + coefr3(4)*px1^1;
r11ap = r11ap + coefr4(1)*py1^4 + coefr4(2)*py1^3 + coefr4(3)*py1^2 + coefr4(4)*py1^1;
r11ap = r11ap + coefr5(1)*pz1^4 + coefr5(2)*pz1^3 + coefr5(3)*pz1^2 + coefr5(4)*pz1^1;
disp('r11ap...');

syms dBxn dByn dBzn dBxnap dBynap dBznap;
syms diffy2 diffx2 diffz2 diffy2ap diffxap diffz2ap;
diffy2 = eval(diff(y2));
diffx2 = diff(x2);
diffz2 = eval(diff(z2));

x0 = 0;
y0 = 0;
z0 = 0;
r1 = 1;
px1 = 2.0;
py1 = 0.0;
pz1 = 0.0;
th1 = 3.14159/2;
ar1 = [th1^4 th1^3 th1^2 th1^1;];
br1 = [eval(diffy2);];
th1 = 3.14159;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; eval(diffy2);];
th1 = 3*3.14159/2;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; eval(diffy2);];
th1 = 2*3.14159;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; eval(diffy2);];
coefr1 = pinv(ar1)*br1;
r1 = 1;
```

```
px1 = 0.0;
pz1 = 0.0;
pz1 = 0.0;
th1 = 0.0;
ar1 = [r1^4 r1^3 r1^2 r1^1;];
br1 = [eval(diffy2) - coefr1(1)*th1^4 - coefr1(2)*th1^3 - coefr1(3)*th1^2 - coefr1(4)*th1^
1;];
r1 = 2;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1;];
br1 = [br1; eval(diffy2) - coefr1(1)*th1^4 - coefr1(2)*th1^3 - coefr1(3)*th1^2 - coefr1(4)
*th1^1;];
r1 = 8;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1;];
br1 = [br1; eval(diffy2) - coefr1(1)*th1^4 - coefr1(2)*th1^3 - coefr1(3)*th1^2 - coefr1(4)
*th1^1;];
r1 = 32;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1;];
br1 = [br1; eval(diffy2) - coefr1(1)*th1^4 - coefr1(2)*th1^3 - coefr1(3)*th1^2 - coefr1(4)
*th1^1;];
coefr2 = pinv(ar1)*br1;
diffy2ap = coefr1(1)*th1^4 + coefr1(2)*th1^3 + coefr1(3)*th1^2 + coefr1(4)*th1^1;
diffy2ap = diffy2ap + coefr2(1)*r1^4 + coefr2(2)*r1^3 + coefr2(3)*r1^2 + coefr2(4)*r1^1;

x0 = 0;
y0 = 0;
z0 = 0;
r1 = 1;
th1 = 3.14159/2;
ar1 = [th1^4 th1^3 th1^2 th1^1;];
br1 = [eval(diffx2);];
th1 = 3.14159;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; eval(diffx2);];
th1 = 3*3.14159/2;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; eval(diffx2);];
th1 = 2*3.14159;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; eval(diffx2);];
coefr1 = pinv(ar1)*br1;
r1 = 1;
ar1 = [r1^4 r1^3 r1^2 r1^1;];
br1 = [eval(diffx2) - coefr1(1)*th1^4 - coefr1(2)*th1^3 - coefr1(3)*th1^2 - coefr1(4)*th1^
1;];
r1 = 2;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1;];
br1 = [br1; eval(diffx2) - coefr1(1)*th1^4 - coefr1(2)*th1^3 - coefr1(3)*th1^2 - coefr1(4)
*th1^1;];
r1 = 8;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1;];
br1 = [br1; eval(diffx2) - coefr1(1)*th1^4 - coefr1(2)*th1^3 - coefr1(3)*th1^2 - coefr1(4)
*th1^1;];
r1 = 32;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1;];
br1 = [br1; eval(diffx2) - coefr1(1)*th1^4 - coefr1(2)*th1^3 - coefr1(3)*th1^2 - coefr1(4)
*th1^1;];
coefr2 = pinv(ar1)*br1;
diffx2ap = coefr1(1)*th1^4 + coefr1(2)*th1^3 + coefr1(3)*th1^2 + coefr1(4)*th1^1;
diffx2ap = diffx2ap + coefr2(1)*r1^4 + coefr2(2)*r1^3 + coefr2(3)*r1^2 + coefr2(4)*r1^1;
x0 = 0;
y0 = 0;
z0 = 0;
r1 = 1;
th1 = 3.14159/2;
ar1 = [th1^4 th1^3 th1^2 th1^1;];
br1 = [diffz2;];
```

```
th1 = 3.14159;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; diffz2;];
th1 = 3*3.14159/2;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; diffz2;];
th1 = 2*3.14159;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; diffz2;];
coefr1 = pinv(ar1)*br1;
r1 = 1;
ar1 = [r1^4 r1^3 r1^2 r1^1;];
br1 = [diffz2 - coefr1(1)*th1^4 - coefr1(2)*th1^3 - coefr1(3)*th1^2 - coefr1(4)*th1^1;];
r1 = 2;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1;];
br1 = [br1; diffz2 - coefr1(1)*th1^4 - coefr1(2)*th1^3 - coefr1(3)*th1^2 - coefr1(4)*th1^
1;];
r1 = 8;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1;];
br1 = [br1; diffz2 - coefr1(1)*th1^4 - coefr1(2)*th1^3 - coefr1(3)*th1^2 - coefr1(4)*th1^
1;];
r1 = 32;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1;];
br1 = [br1; diffz2 - coefr1(1)*th1^4 - coefr1(2)*th1^3 - coefr1(3)*th1^2 - coefr1(4)*th1^
1;];
coefr2 = pinv(ar1)*br1;
diffz2ap = coefr1(1)*th1^4 + coefr1(2)*th1^3 + coefr1(3)*th1^2 + coefr1(4)*th1^1;
diffz2ap = diffz2ap + coefr2(1)*r1^4 + coefr2(2)*r1^3 + coefr2(3)*r1^2 + coefr2(4)*r1^1;


syms r1 th1 px1 py1 pz1;
dBxn = eval(diffy2ap*r1z - r1y*diffz2ap);
dByn = eval(diffx2ap*r1z - r1x*diffz2ap);
dBzn = eval(diffx2ap*r1y - r1x*diffy2ap);
%;ar1 = [r1 px1 py1 pz1]

th1 = 0.0;
px1 = 2.0;
py1 = 0.0;
pz1 = 0.0;
r1 = 2;
ar1 = [r1^4 r1^3 r1^2 r1^1;];
br1 = [eval(dBxn);];
r1 = 8;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1;];
br1 = [br1; eval(dBxn);];
r1 = 16;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1;];
br1 = [br1; eval(dBxn);];
r1 = 48;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1;];
br1 = [br1; eval(dBxn);];
coefr1 = pinv(ar1)*real(br1);
disp('coefr1...');
px1 = 0.0;
py1 = 0.0;
pz1 = 0.0;
r1 = 1.0;
th1 = 3.14159/2;
ar1 = [th1^4 th1^3 th1^2 th1^1;];
br1 = [eval(dBxn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;];
th1 = 3.14159;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; eval(dBxn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^
1;];
th1 = 3*3.14159/2;
```

```
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; eval(dBxn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^
1;];
th1 = 2*3.14159;
r1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; eval(dBxn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^
1;];
coefr2 = pinv(ar1)*real(br1);
disp('coefr2...');
py1 = 0.0;
pz1 = 0.0;
r1 = 1.0;
th1 = 0.0;
px1 = 2;
ar1 = [px1^4 px1^3 px1^2 px1^1;];
atmp = eval(dBxn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
br1 = [atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;];
px1 = 8;
ar1 = [ar1; px1^4 px1^3 px1^2 px1^1;];
atmp = eval(dBxn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
br1 = [br1; atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^
1;];
px1 = 18;
ar1 = [ar1; px1^4 px1^3 px1^2 px1^1;];
atmp = eval(dBxn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
br1 = [br1; atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^
1;];
px1 = 48;
ar1 = [ar1; px1^4 px1^3 px1^2 px1^1;];
atmp = eval(dBxn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
br1 = [br1; atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^
1;];
coefr3 = pinv(ar1)*real(br1);
disp('coefr3...');
px1 = 0.0;
pz1 = 0.0;
th1 = 0.0;
r1 = 0.0;
py1 = 2;
ar1 = [py1^4 py1^3 py1^2 py1^1;];
atmp = eval(dBxn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;];
py1 = 8;
ar1 = [ar1; py1^4 py1^3 py1^2 py1^1;];
atmp = eval(dBxn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [br1; atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^
1;];
py1 = 18;
ar1 = [ar1; py1^4 py1^3 py1^2 py1^1;];
atmp = eval(dBxn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [br1; atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^
1;];
py1 = 48;
ar1 = [ar1; py1^4 py1^3 py1^2 py1^1;];
atmp = eval(dBxn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [br1; atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^
1;];
coefr4 = pinv(ar1)*real(br1);
disp('coefr4...');
px1 = 0.0;
py1 = 0.0;
th1 = 0.0;
```

```
r1 = 0.0;
pz1 = 2;
ar1 = [pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = eval(dBxn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp  = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^1;];
pz1 = 8;
ar1 = [ar1; pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = eval(dBxn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp  = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [br1; atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^
1;];
pz1 = 32;
ar1 = [ar1; pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = eval(dBxn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp  = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [br1; atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^
1;];
pz1 = 48;
ar1 = [ar1; pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = eval(dBxn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp  = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [br1; atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^
1;];
coefr5 = pinv(ar1)*real(br1);
disp('coefr5...');
syms r1 th1 px1 py1 pz1;
dBxnap = coefr1(1)*r1^4 + coefr1(2)*r1^3 + coefr1(3)*r1^2 + coefr1(4)*r1^1;
dBxnap = dBxnap + coefr2(1)*th1^4 + coefr2(2)*th1^3 + coefr2(3)*th1^2 + coefr2(4)*th1^1;
dBxnap = dBxnap + coefr3(1)*px1^4 + coefr3(2)*px1^3 + coefr3(3)*px1^2 + coefr3(4)*px1^1;
dBxnap = dBxnap + coefr4(1)*py1^4 + coefr4(2)*py1^3 + coefr4(3)*py1^2 + coefr4(4)*py1^1;
dBxnap = dBxnap + coefr5(1)*pz1^4 + coefr5(2)*pz1^3 + coefr5(3)*pz1^2 + coefr5(4)*pz1^1;
disp('dBxnap...');

syms r1 th1 px1 py1 pz1;

r1 = 1.0;
px1 = 2.0;
py1 = 0.0;
pz1 = 0.0;
ar1 = [r1^4 r1^3 r1^2 r1^1;];
br1 = [eval(dByn);];
r1 = 8;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1;];
br1 = [br1; eval(dByn);];
r1 = 16;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1;];
br1 = [br1; eval(dByn);];
r1 = 48;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1;];
br1 = [br1; eval(dByn);];
coefr1 = pinv(ar1)*real(br1);
disp('coefr1...');
th1 = 3.14159/2;
ar1 = [th1^4 th1^3 th1^2 th1^1;];
br1 = [eval(dByn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;];
th1 = 3.14159;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; eval(dByn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^
1;];
th1 = 3*3.14159/2;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
```

```
br1 = [br1; eval(dByn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^
1;];
th1 = 2*3.14159;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; eval(dByn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^
1;];
coefr2 = pinv(ar1)*real(br1);
disp('coefr2...');
py1 = 0.0;
pz1 = 0.0;
th1 = 0.0;
r1 = 1.0;
px1 = 2;
ar1 = [px1^4 px1^3 px1^2 px1^1;];
atmp = eval(dByn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
br1 = [atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;];
px1 = 8;
ar1 = [ar1; px1^4 px1^3 px1^2 px1^1;];
atmp = eval(dByn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
br1 = [br1; atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^
1;];
px1 = 18;
ar1 = [ar1; px1^4 px1^3 px1^2 px1^1;];
atmp = eval(dByn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
br1 = [br1; atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^
1;];
px1 = 48;
ar1 = [ar1; px1^4 px1^3 px1^2 px1^1;];
atmp = eval(dByn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
br1 = [br1; atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^
1;];
coefr3 = pinv(ar1)*real(br1);
disp('coefr3...');
px1 = 0.0;
pz1 = 0.0;
th1 = 0.0;
r1 = 1.0;
py1 = 2;
ar1 = [py1^4 py1^3 py1^2 py1^1;];
atmp = eval(dByn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;];
py1 = 8;
ar1 = [ar1; py1^4 py1^3 py1^2 py1^1;];
atmp = eval(dByn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [br1; atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^
1;];
py1 = 18;
ar1 = [ar1; py1^4 py1^3 py1^2 py1^1;];
atmp = eval(dByn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [br1; atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^
1;];
py1 = 48;
ar1 = [ar1; py1^4 py1^3 py1^2 py1^1;];
atmp = eval(dByn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [br1; atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^
1;];
coefr4 = pinv(ar1)*real(br1);
disp('coefr4...');
px1 = 0.0;
py1 = 0.0;
th1 = 0.0;
r1 = 1.0;
```

```matlab
pz1 = 2;
ar1 = [pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = eval(dByn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp  = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^1;];
pz1 = 8;
ar1 = [ar1; pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = eval(dByn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp  = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [br1; atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^
1;];
pz1 = 32;
ar1 = [ar1; pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = eval(dByn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp  = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [br1; atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^
1;];
pz1 = 48;
ar1 = [ar1; pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = eval(dByn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp  = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [br1; atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^
1;];
coefr5 = pinv(ar1)*real(br1);
disp('coefr5...');
syms r1 th1 px1 py1 pz1;
dBynap = coefr1(1)*r1^4 + coefr1(2)*r1^3 + coefr1(3)*r1^2 + coefr1(4)*r1^1;
dBynap = dBynap + coefr2(1)*th1^4 + coefr2(2)*th1^3 + coefr2(3)*th1^2 + coefr2(4)*th1^1;
dBynap = dBynap + coefr3(1)*px1^4 + coefr3(2)*px1^3 + coefr3(3)*px1^2 + coefr3(4)*px1^1;
dBynap = dBynap + coefr4(1)*py1^4 + coefr4(2)*py1^3 + coefr4(3)*py1^2 + coefr4(4)*py1^1;
dBynap = dBynap + coefr5(1)*pz1^4 + coefr5(2)*pz1^3 + coefr5(3)*pz1^2 + coefr5(4)*pz1^1;
disp('dBynap...');

syms r1 th1 px1 py1 pz1;

px1 = 2.0;
py1 = 0.0;
pz1 = 0.0;
th1 = 0.0;
r1 = 1.0;
ar1 = [r1^4 r1^3 r1^2 r1^1;];
br1 = [dBzn;];
r1 = 8;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1;];
br1 = [br1; dBzn;];
r1 = 16;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1;];
br1 = [br1; dBzn;];
r1 = 48;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1;];
br1 = [br1; dBzn;];
coefr1 = pinv(ar1)*real(br1);
disp('coefr1...');
px1 = 0.0;
py1 = 0.0;
pz1 = 0.0;
r1 = 1.0;
th1 = 3.14159/2;
ar1 = [th1^4 th1^3 th1^2 th1^1;];
br1 = [dBzn - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;];
th1 = 3.14159;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
```

```
br1 = [br1; dBzn - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;];
th1 = 3*3.14159/2;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; dBzn - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;];
th1 = 2*3.14159;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; dBzn - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;];
coefr2 = pinv(ar1)*real(br1);
disp('coefr2...');
py1 = 0.0;
pz1 = 0.0;
th1 = 0.0;
r1 = 1.0;
px1 = 2;
ar1 = [px1^4 px1^3 px1^2 px1^1;];
atmp = dBzn - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
br1 = [atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;];
px1 = 8;
ar1 = [ar1; px1^4 px1^3 px1^2 px1^1;];
atmp = dBzn - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
br1 = [br1; atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^
1;];
px1 = 18;
ar1 = [ar1; px1^4 px1^3 px1^2 px1^1;];
atmp = dBzn - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
br1 = [br1; atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^
1;];
px1 = 48;
ar1 = [ar1; px1^4 px1^3 px1^2 px1^1;];
atmp = dBzn - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
br1 = [br1; atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^
1;];
coefr3 = pinv(ar1)*real(br1);
disp('coefr3...');
px1 = 0.0;
pz1 = 0.0;
th1 = 0.0;
r1 = 1.0;
py1 = 2;
ar1 = [py1^4 py1^3 py1^2 py1^1;];
atmp = dBzn - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;];
py1 = 8;
ar1 = [ar1; py1^4 py1^3 py1^2 py1^1;];
atmp = dBzn - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [br1; atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^
1;];
py1 = 18;
ar1 = [ar1; py1^4 py1^3 py1^2 py1^1;];
atmp = dBzn - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [br1; atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^
1;];
py1 = 48;
ar1 = [ar1; py1^4 py1^3 py1^2 py1^1;];
atmp = dBzn - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [br1; atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^
1;];
coefr4 = pinv(ar1)*real(br1);
disp('coefr4...');
px1 = 0.0;
py1 = 0.0;
r1 = 1.0;
```

```
th1 = 0.0;
pz1 = 2;
ar1 = [pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = dBzn - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^1;];
pz1 = 8;
ar1 = [ar1; pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = dBzn - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [br1; atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^
1;];
pz1 = 32;
ar1 = [ar1; pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = dBzn - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [br1; atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^
1;];
pz1 = 48;
ar1 = [ar1; pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = dBzn - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [br1; atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^
1;];
coefr5 = pinv(ar1)*real(br1);
disp('coefr5...');
syms r1 th1 px1 py1 pz1;
dBznap = coefr1(1)*r1^4 + coefr1(2)*r1^3 + coefr1(3)*r1^2 + coefr1(4)*r1^1;
dBznap = dBznap + coefr2(1)*th1^4 + coefr2(2)*th1^3 + coefr2(3)*th1^2 + coefr2(4)*th1^1;
dBznap = dBznap + coefr3(1)*px1^4 + coefr3(2)*px1^3 + coefr3(3)*px1^2 + coefr3(4)*px1^1;
dBznap = dBznap + coefr4(1)*py1^4 + coefr4(2)*py1^3 + coefr4(3)*py1^2 + coefr4(4)*py1^1;
dBznap = dBznap + coefr5(1)*pz1^4 + coefr5(2)*pz1^3 + coefr5(3)*pz1^2 + coefr5(4)*pz1^1;
disp('dBznap...');

syms r1 th1 px1 py1 pz1;

r1 = 1.0;
th1 = 0.0;
px1 = 2.0;
py1 = 0.0;
pz1 = 0.0;
ar1 = [r1^4 r1^3 r1^2 r1^1;];
br1 = [real(eval(dBxnap)/eval(r11ap));];
px1 = 8;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1;];
br1 = [br1; real(eval(dBxnap)/eval(r11ap));];
px1 = 16;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1;];
br1 = [br1; real(eval(dBxnap)/eval(r11ap));];
px1 = 48;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1;];
br1 = [br1; real(eval(dBxnap)/eval(r11ap));];
coefr1 = pinv(ar1)*real(br1);
disp('coefr1...');
px1 = 0.0;
py1 = 0.0;
pz1 = 0.0;
r1 = 1.0;
th1 = 3.14159/2;
ar1 = [th1^4 th1^3 th1^2 th1^1;];
br1 = [real(eval(dBxnap)/eval(r11ap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;];
```

```
th1 = 3.14159;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; real(eval(dBxnap)/eval(r11ap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)
*r1^2 - coefr1(4)*r1^1;];
th1 = 3*3.14159/2;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; real(eval(dBxnap)/eval(r11ap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)
*r1^2 - coefr1(4)*r1^1;];
th1 = 2*3.14159;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; real(eval(dBxnap)/eval(r11ap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)
*r1^2 - coefr1(4)*r1^1;];
coefr2 = pinv(ar1)*real(br1);
disp('coefr2...');
px1 = 2.0;
py1 = 0.0;
th1 = 0.0;
r1 = 1.0;
ar1 = [px1^4 px1^3 px1^2 px1^1;];
atmp = real(eval(dBxnap)/eval(r11ap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
br1 = [atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;];
px1 = 8;
ar1 = [ar1; px1^4 px1^3 px1^2 px1^1;];
atmp = real(eval(dBxnap)/eval(r11ap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
br1 = [br1; atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^
1;];
px1 = 18;
ar1 = [ar1; px1^4 px1^3 px1^2 px1^1;];
atmp = real(eval(dBxnap)/eval(r11ap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
br1 = [br1; atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^
;];
px1 = 48;
ar1 = [ar1; px1^4 px1^3 px1^2 px1^1;];
atmp = real(eval(dBxnap)/eval(r11ap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
br1 = [br1; atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^
1;];
coefr3 = pinv(ar1)*real(br1);
disp('coefr3...');
px1 = 0.0;
pz1 = 0.0;
th1 = 0.0;
r1 = 1.0;
py1 = 2;
ar1 = [py1^4 py1^3 py1^2 py1^1;];
atmp = real(eval(dBxnap)/eval(r11ap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;];
py1 = 8;
ar1 = [ar1; py1^4 py1^3 py1^2 py1^1;];
atmp = real(eval(dBxnap)/eval(r11ap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [br1; atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^
1;];
py1 = 18;
ar1 = [ar1; py1^4 py1^3 py1^2 py1^1;];
atmp = real(eval(dBxnap)/eval(r11ap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [br1; atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^
1;];
```

```matlab
py1 = 48;
ar1 = [ar1; py1^4 py1^3 py1^2 py1^1;];
atmp = real(eval(dBxnap)/eval(r11ap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
atmp  = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [br1; atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^
1;];
coefr4 = pinv(ar1)*real(br1);
disp('coefr4...');
px1 = 0.0;
py1 = 0.0;
th1 = 0.0;
r1 = 1.0;
pz1 = 2;
ar1 = [pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = real(eval(dBxnap)/eval(r11ap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
atmp  = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^1;];
pz1 = 8;
ar1 = [ar1; pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = real(eval(dBxnap)/eval(r11ap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
atmp  = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [br1; atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^
1;];
pz1 = 32;
ar1 = [ar1; pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = real(eval(dBxnap)/eval(r11ap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
atmp  = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [br1; atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^
1;];
pz1 = 48;
ar1 = [ar1; pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = real(eval(dBxnap)/eval(r11ap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
atmp  = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [br1; atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^
1;];
coefr5 = pinv(ar1)*real(br1);
disp('coefr5...');
syms r1 th1 px1 py1 pz1;
dBx = coefr1(1)*r1^4 + coefr1(2)*r1^3 + coefr1(3)*r1^2 + coefr1(4)*r1^1;
dBx = dBx + coefr2(1)*th1^4 + coefr2(2)*th1^3 + coefr2(3)*th1^2 + coefr2(4)*th1^1;
dBx = dBx + coefr3(1)*px1^4 + coefr3(2)*px1^3 + coefr3(3)*px1^2 + coefr3(4)*px1^1;
dBx = dBx + coefr4(1)*py1^4 + coefr4(2)*py1^3 + coefr4(3)*py1^2 + coefr4(4)*py1^1;
dBx = dBx + coefr5(1)*pz1^4 + coefr5(2)*pz1^3 + coefr5(3)*pz1^2 + coefr5(4)*pz1^1;
disp('dBx...');


r1 = 1.0;

circle1x = u0*int(dBx,th1,0,2*3.14159);
disp('finished circle1x...');

fprintf(fid,'\n\nCircle1x = Sum of: \n');
for i1 = 1:4
   fprintf(fid,'%20.12f',coefr1(i1));
   fprintf(fid,' px1^%1i',i1);
   fprintf(fid,'\n');
end
```

```matlab
for i1 = 1:4
  fprintf(fid,'%20.12f',coefr2(i1));
  fprintf(fid,' py1^%1i',i1);
  fprintf(fid,'\n');
end
for i1 = 1:4
  fprintf(fid,'%20.12f',coefr3(i1));
  fprintf(fid,' pz1^%1i',i1);
  fprintf(fid,'\n');
end
for i1 = 1:4
  fprintf(fid,'%20.12f',coefr4(i1));
  fprintf(fid,' th1^%1i',i1);
  fprintf(fid,'\n');
end
for i1 = 1:4
  fprintf(fid,'%20.12f',coefr5(i1));
  fprintf(fid,' th2^%1i',i1);
  fprintf(fid,'\n');
end
syms tcircle1x tcircle1y tcircle1z test1 test2 test3 test4 test5;
tcircle1x = coefr1(1)*test1^4 + coefr1(2)*test1^3 + coefr1(3)*test1^2 + coefr1(4)*test1^1;
tcircle1x = tcircle1x + coefr2(1)*test2^4 + coefr2(2)*test2^3 + coefr2(3)*test2^2 + coefr2(4)*test2^1;
tcircle1x = tcircle1x + coefr3(1)*test3^4 + coefr3(2)*test3^3 + coefr3(3)*test3^2 + coefr3(4)*test3^1;
tcircle1x = tcircle1x + coefr4(1)*test4^4 + coefr4(2)*test4^3 + coefr4(3)*test4^2 + coefr4(4)*test4^1;
tcircle1x = tcircle1x + coefr5(1)*test5^4 + coefr5(2)*test5^3 + coefr5(3)*test5^2 + coefr5(4)*test5^1;
test1 = 2*r1;
test2 = 0.0;
test3 = 0.0;
test4 = 0.0;
test5 = 0.0;
fprintf(fid,'\n\nTest of circle1x:');
fprintf(fid,'\npx1 = %20.12f',test1);
fprintf(fid,'\npy1 = %20.12f',test2);
fprintf(fid,'\npz1 = %20.12f',test3);
fprintf(fid,'\nth1 = %20.12f',test4);
fprintf(fid,'\nth2 = %20.12f',test5);
fprintf(fid,'\ncircle1x = %20.12f',eval(tcircle1x));
fprintf(fid,'\n');


syms r1 th1 px1 py1 pz1;

r1 = 1.0;
th1 = 0.0;
px1 = 0.0;
py1 = 0.0;
pz1 = 0.0;
ar1 = [r1^4 r1^3 r1^2 r1^1;];
br1 = [real(eval(dBynap)/eval(r11ap));];
r1 = 8;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1;];
br1 = [br1; real(eval(dBynap)/eval(r11ap));];
r1 = 16;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1;];
br1 = [br1; real(eval(dBynap)/eval(r11ap));];
r1 = 48;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1;];
br1 = [br1; real(eval(dBynap)/eval(r11ap));];
coefr1 = pinv(ar1)*real(br1);
disp('coefr1...');
px1 = 0.0;
```

```
py1 = 0.0;
th1 = 0.0;
r1 = 1.0;
th1 = 20;
r1 = [th1^4 th1^3 th1^2 th1^1;];
br1 = [real(eval(dBynap)/eval(r11ap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;];
th1 = 80;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; real(eval(dBynap)/eval(r11ap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)
*r1^2 - coefr1(4)*r1^1;];
th1 = 320;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; real(eval(dBynap)/eval(r11ap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)
*r1^2 - coefr1(4)*r1^1;];
th1 = 720;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; real(eval(dBynap)/eval(r11ap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)
*r1^2 - coefr1(4)*r1^1;];
coefr2 = pinv(ar1)*real(br1);
disp('coefr2...');
py1 = 0.0;
px1 = 0.0;
r1 = 1.0;
th1 = 0.0;
pz1 = 2;
ar1 = [px1^4 px1^3 px1^2 px1^1;];
atmp = real(eval(dBynap)/eval(r11ap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
br1 = [atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;];
pz1 = 8;
ar1 = [ar1; px1^4 px1^3 px1^2 px1^1;];
atmp = real(eval(dBynap)/eval(r11ap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
br1 = [br1; atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^
1;];
pz1 = 18;
ar1 = [ar1; px1^4 px1^3 px1^2 px1^1;];
atmp = real(eval(dBynap)/eval(r11ap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
br1 = [br1; atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^
1;];
pz1 = 48;
ar1 = [ar1; px1^4 px1^3 px1^2 px1^1;];
atmp = real(eval(dBynap)/eval(r11ap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
br1 = [br1; atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^
1;];
coefr3 = pinv(ar1)*real(br1);
disp('coefr3...');
px1 = 0.0;
pz1 = 0.0;
r1 = 1.0;
th1 = 0.0;
py1 = 2;
ar1 = [py1^4 py1^3 py1^2 py1^1;];
atmp = real(eval(dBynap)/eval(r11ap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;];
py1 = 8;
ar1 = [ar1; py1^4 py1^3 py1^2 py1^1;];
atmp = real(eval(dBynap)/eval(r11ap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [br1; atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^
```

```
1;];
py1 = 18;
ar1 = [ar1; py1^4 py1^3 py1^2 py1^1;];
atmp = real(eval(dBynap)/eval(r11ap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [br1; atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^
1;];
py1 = 48;
ar1 = [ar1; py1^4 py1^3 py1^2 py1^1;];
atmp = real(eval(dBynap)/eval(r11ap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [br1; atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^
1;];
coefr4 = pinv(ar1)*real(br1);
disp('coefr4...');
px1 = 0.0;
py1 = 0.0;
r1 = 1.0;
th1 = 0.0;
pz1 = 2;
ar1 = [pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = real(eval(dBynap)/eval(r11ap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^1;];
pz1 = 8;
ar1 = [ar1; pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = real(eval(dBynap)/eval(r11ap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [br1; atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^
1;];
pz1 = 32;
ar1 = [ar1; pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = real(eval(dBynap)/eval(r11ap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [br1; atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^
1;];
pz1 = 48;
ar1 = [ar1; pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = real(eval(dBynap)/eval(r11ap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [br1; atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^
1;];
coefr5 = pinv(ar1)*real(br1);
disp('coefr5...');
syms r1 th1 px1 py1 pz1;
dBy = coefr1(1)*r1^4 + coefr1(2)*r1^3 + coefr1(3)*r1^2 + coefr1(4)*r1^1;
dBy = dBy + coefr2(1)*th1^4 + coefr2(2)*th1^3 + coefr2(3)*th1^2 + coefr2(4)*th1^1;
dBy = dBy + coefr3(1)*px1^4 + coefr3(2)*px1^3 + coefr3(3)*px1^2 + coefr3(4)*px1^1;
dBy = dBy + coefr4(1)*py1^4 + coefr4(2)*py1^3 + coefr4(3)*py1^2 + coefr4(4)*py1^1;
dBy = dBy + coefr5(1)*pz1^4 + coefr5(2)*pz1^3 + coefr5(3)*pz1^2 + coefr5(4)*pz1^1;
disp('dBy...');

r1 = 1.0;

circle1y = u0*int(dBy,th1,0,2*3.14159);
disp('finished circle1y...');
```

```matlab
fprintf(fid,'\n\nCircle1y = Sum of: \n');
for i1 = 1:4
  fprintf(fid,'%20.12f',coefr1(i1));
  fprintf(fid,' px1^%1i',i1);
  fprintf(fid,'\n');
end
for i1 = 1:4
  fprintf(fid,'%20.12f',coefr2(i1));
  fprintf(fid,' py1^%1i',i1);
  fprintf(fid,'\n');
end
for i1 = 1:4
  fprintf(fid,'%20.12f',coefr3(i1));
  fprintf(fid,' pz1^%1i',i1);
  fprintf(fid,'\n');
end
for i1 = 1:4
  fprintf(fid,'%20.12f',coefr4(i1));
  fprintf(fid,' th1^%1i',i1);
  fprintf(fid,'\n');
end
for i1 = 1:4
  fprintf(fid,'%20.12f',coefr5(i1));
  fprintf(fid,' th2^%1i',i1);
  fprintf(fid,'\n');
end
syms test1 test2 test3 test4 test5;
tcircle1y = coefr1(1)*test1^4 + coefr1(2)*test1^3 + coefr1(3)*test1^2 + coefr1(4)*test1^1;
tcircle1y = tcircle1y + coefr2(1)*test2^4 + coefr2(2)*test2^3 + coefr2(3)*test2^2 + coefr2(4)*test2^1;
tcircle1y = tcircle1y + coefr3(1)*test3^4 + coefr3(2)*test3^3 + coefr3(3)*test3^2 + coefr3(4)*test3^1;
tcircle1y = tcircle1y + coefr4(1)*test4^4 + coefr4(2)*test4^3 + coefr4(3)*test4^2 + coefr4(4)*test4^1;
tcircle1y = tcircle1y + coefr5(1)*test5^4 + coefr5(2)*test5^3 + coefr5(3)*test5^2 + coefr5(4)*test5^1;
test1 = 2*r1;
test2 = 0.0;
test3 = 0.0;
test4 = 0.0;
test5 = 0.0;
fprintf(fid,'\n\nTest of circle1y:');
fprintf(fid,'\npx1 = %20.12f',test1);
fprintf(fid,'\npy1 = %20.12f',test2);
fprintf(fid,'\npz1 = %20.12f',test3);
fprintf(fid,'\nth1 = %20.12f',test4);
fprintf(fid,'\nth2 = %20.12f',test5);
fprintf(fid,'\ncircle1y = %20.12f',eval(tcircle1y));
fprintf(fid,'\n');


syms r1 th1 px1 py1 pz1;

px1 = 0.0;
py1 = 0.0;
pz1 = 0.0;
th1 = 0.0;
r1 = 2;
ar1 = [r1^4 r1^3 r1^2 r1^1;];
br1 = [real(eval(dBznap)/eval(r11ap));];
r1 = 8;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1;];
br1 = [br1; real(eval(dBznap)/eval(r11ap));];
r1 = 16;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1;];
```

```
br1 = [br1; real(eval(dBznap)/eval(r11ap));];
r1 = 48;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1;];
br1 = [br1; real(eval(dBznap)/eval(r11ap));];
coefr1 = pinv(ar1)*real(br1);
disp('coefr1...');
px1 = 0.0;
py1 = 0.0;
pz1 = 0.0;
r1 = 1.0;
th1 = 3.14159/2;
ar1 = [th1^4 th1^3 th1^2 th1^1;];
br1 = [real(eval(dBznap)/eval(r11ap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;];
th1 = 3.14159;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; real(eval(dBznap)/eval(r11ap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)
*r1^2 - coefr1(4)*r1^1;];
th1 = 3*3.14159/2;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; real(eval(dBznap)/eval(r11ap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)
*r1^2 - coefr1(4)*r1^1;];
th1 = 2*3.14159;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; real(eval(dBznap)/eval(r11ap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)
*r1^2 - coefr1(4)*r1^1;];
coefr2 = pinv(ar1)*real(br1);
disp('coefr2...');
py1 = 0.0;
pz1 = 0.0;
r1 = 1.0;
th1 = 0.0;
px1 = 2;
ar1 = [px1^4 px1^3 px1^2 px1^1;];
atmp = real(eval(dBznap)/eval(r11ap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
br1 = [atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;];
px1 = 8;
ar1 = [ar1; px1^4 px1^3 px1^2 px1^1;];
atmp = real(eval(dBznap)/eval(r11ap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
br1 = [br1; atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^
1;];
px1 = 18;
ar1 = [ar1; px1^4 px1^3 px1^2 px1^1;];
atmp = real(eval(dBznap)/eval(r11ap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
br1 = [br1; atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^
1;];
px1 = 48;
ar1 = [ar1; px1^4 px1^3 px1^2 px1^1;];
atmp = real(eval(dBznap)/eval(r11ap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
br1 = [br1; atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^
1;];
coefr3 = pinv(ar1)*real(br1);
disp('coefr3...');
px1 = 0.0;
pz1 = 0.0;
r1 = 1.0;
th1 = 0.0;
py1 = 2;
ar1 = [py1^4 py1^3 py1^2 py1^1;];
atmp = real(eval(dBznap)/eval(r11ap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
atmp  = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
```

```
br1 = [atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;];
py1 = 8;
ar1 = [ar1; py1^4 py1^3 py1^2 py1^1;];
atmp = real(eval(dBznap)/eval(r11ap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [br1; atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^
1;];
py1 = 16;
ar1 = [ar1; py1^4 py1^3 py1^2 py1^1;];
atmp = real(eval(dBznap)/eval(r11ap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [br1; atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^
1;];
py1 = 64;
ar1 = [ar1; py1^4 py1^3 py1^2 py1^1;];
atmp = real(eval(dBznap)/eval(r11ap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [br1; atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^
1;];
coefr4 = pinv(ar1)*real(br1);
disp('coefr4...');
px1 = 0.0;
py1 = 0.0;
r1 = 1.0;
th1 = 0.0;
pz1 = 2;
ar1 = [pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = real(eval(dBznap)/eval(r11ap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^1;];
pz1 = 8;
ar1 = [ar1; pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = real(eval(dBznap)/eval(r11ap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [br1; atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^
1;];
pz1 = 32;
ar1 = [ar1; pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = real(eval(dBznap)/eval(r11ap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [br1; atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^
1;];
pz1 = 48;
ar1 = [ar1; pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = real(eval(dBznap)/eval(r11ap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [br1; atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^
1;];
coefr5 = pinv(ar1)*real(br1);
disp('coefr5...');
syms r1 th1 px1 py1 pz1;
dBz = coefr1(1)*r1^4 + coefr1(2)*r1^3 + coefr1(3)*r1^2 + coefr1(4)*r1^1;
dBz = dBz + coefr2(1)*th1^4 + coefr2(2)*th1^3 + coefr2(3)*th1^2 + coefr2(4)*th1^1;
dBz = dBz + coefr3(1)*px1^4 + coefr3(2)*px1^3 + coefr3(3)*px1^2 + coefr3(4)*px1^1;
dBz = dBz + coefr4(1)*py1^4 + coefr4(2)*py1^3 + coefr4(3)*py1^2 + coefr4(4)*py1^1;
```

```
dBz = dBz + coefr5(1)*pz1^4 + coefr5(2)*pz1^3 + coefr5(3)*pz1^2 + coefr5(4)*pz1^1;
disp('dBz...');


1 = 1.0;

circle1z = u0*int(dBz,th1,0,2*3.14159);
disp('finished circle1z...');

fprintf(fid,'\n\nCircle1z = Sum of: \n');
for i1 = 1:4
   fprintf(fid,'%20.12f',coefr1(i1));
   fprintf(fid,' px1^%1i',i1);
   fprintf(fid,'\n');
end
for i1 = 1:4
   fprintf(fid,'%20.12f',coefr2(i1));
   fprintf(fid,' py1^%1i',i1);
   fprintf(fid,'\n');
end
for i1 = 1:4
   fprintf(fid,'%20.12f',coefr3(i1));
   fprintf(fid,' pz1^%1i',i1);
   fprintf(fid,'\n');
end
for i1 = 1:4
   fprintf(fid,'%20.12f',coefr4(i1));
   fprintf(fid,' th1^%1i',i1);
   fprintf(fid,'\n');
end
for i1 = 1:4
   fprintf(fid,'%20.12f',coefr5(i1));
   fprintf(fid,' th2^%1i',i1);
   fprintf(fid,'\n');
end
syms test1 test2 test3 test4 test5;
tcircle1z = coefr1(1)*test1^4 + coefr1(2)*test1^3 + coefr1(3)*test1^2 + coefr1(4)*test1^1;
tcircle1z = tcircle1z + coefr2(1)*test2^4 + coefr2(2)*test2^3 + coefr2(3)*test2^2 + coefr2(4)*test2^1;
tcircle1z = tcircle1z + coefr3(1)*test3^4 + coefr3(2)*test3^3 + coefr3(3)*test3^2 + coefr3(4)*test3^1;
tcircle1z = tcircle1z + coefr4(1)*test4^4 + coefr4(2)*test4^3 + coefr4(3)*test4^2 + coefr4(4)*test4^1;
tcircle1z = tcircle1z + coefr5(1)*test5^4 + coefr5(2)*test5^3 + coefr5(3)*test5^2 + coefr5(4)*test5^1;
test1 = 2*r1;
test2 = 0.0;
test3 = 0.0;
test4 = 0.0;
test5 = 0.0;
fprintf(fid,'\n\nTest of circle1z:');
fprintf(fid,'\npx1 = %20.12f',test1);
fprintf(fid,'\npy1 = %20.12f',test2);
fprintf(fid,'\npz1 = %20.12f',test3);
fprintf(fid,'\nth1 = %20.12f',test4);
fprintf(fid,'\nth2 = %20.12f',test5);
fprintf(fid,'\ncircle1z = %20.12f',eval(tcircle1z));
fprintf(fid,'\n');


syms r1 th1 px1 py1 pz1;


%; dBx = diff(y2)*r1z - r1y*diff(z2)/r11^2;
%; dBy = diff(x2)*r1z - r1x*diff(z2)/r11^2;
%; dBz = diff(x2)*r1y - r1x*diff(y2)/r11^2;
```

```
disp('finished symbolic computation of dB...');

%;fprintf(fid,'\ndBx = ');
%;fprintf(fid,char(dBx));
%;fprintf(fid,'\ndBy = ');
%;fprintf(fid,char(dBy));
%;fprintf(fid,'\ndBz = ');
%;fprintf(fid,char(dBz));
%;fprintf(fid,'\n');
%;disp('finished symbolic computation of dBx, dby, dBz...');
%;




%;
%; This next section takes too long, so it has to be converted into polynomial matrices
%;



px1t = px1;
py1t = py1;
pz1t = pz1;
th1t = th1;
th2t = th2;




%;
%; compute the torus equation
%;    - Rt  = radius of torus
%;    - Ot  = origin of torus
%;    - Or  = origin of ring
%;    - Tht = angle of ring in x-y plane
%;    - Thtn = angle of torus in x-y plane
%;    - ...coordinates in torus
%;    - 28 points generated by for loop to 28 points generated by loop
%;    - looking for a 28x28 matrix to multiply each point by...
%;    - Therefor you need 28 matrices to have a solution for each row
%;    - Now use this matrix to generate the cumulative torus equation
%;    - ...with a for loop on the individual equations
%;

%;
%;
%;
syms thcum rpt xpt ypt thpt Rt Otx Oty Otz Or Tht nr thp torus1x torus1y torus1z;
syms coef6 coef7 coef8 coef9 coef10 coef11 coef12 coef13 coef14 toruseq1x toruseq1y
toruseq1z;
syms k1 k2 k3 k4 tmp1 Thtn thT;
syms Rtt Otxt Otyt Otzt Thtt Thtnt;




r1 = 1.0;
Otx = 0;
Oty = 0;
Otz = 0;
xpt = Otx + Rt*cos(Tht);
ypt = Oty + Rt*sin(Tht);
rpt = sqrt((xpt - Otx)^2 + (ypt - Oty)^2);
xt = Otx + Rt*cos(Tht);
yt = Oty + Rt*sin(Tht);
```

```matlab
%;thpt = itan1(xt,yt);
syms thpt;
thcum = thpt + Thtn;
x0 = rpt*cos(thcum);
y0 = rpt*sin(thcum);
th1 = Tht;
th2 = 0;
nr = 8;
thp = 2*3.14159/nr;
Tht = thp*i1;
Rt = 20;
torus1x = 0;
for i1 = 1:nr
  thpt= itan1(eval(xt),eval(yt));
  torus1x = torus1x + circle1x;
end
a1 = [Rt^4 Rt^3 Rt^2 Rt^1;];
b1 = [eval(torus1x);];
Rt = 60;
torus1x = 0;
for i1 = 1:nr
  thpt= itan1(eval(xt),eval(yt));
  torus1x = torus1x + circle1x;
end
a1 = [a1; Rt^4 Rt^3 Rt^2 Rt^1;];
b1 = [b1; eval(torus1x);];
Rt = 240;
torus1x = 0;
for i1 = 1:nr
  thpt= itan1(eval(xt),eval(yt));
  torus1x = torus1x + circle1x;
end
a1 = [a1; Rt^4 Rt^3 Rt^2 Rt^2;];
b1 = [b1; eval(torus1x);];
Rt = 2400;
torus1x = 0;
for i1 = 1:nr
  thpt= itan1(eval(xt),eval(yt));
  torus1x = torus1x + circle1x;
end
a1 = [a1; Rt^4 Rt^3 Rt^2 Rt^2;];
b1 = [b1; eval(torus1x);];
%;
%; The following is the first set of coefficients of the torus equation for Rt = variable
%;
coef6 = pinv(a1)*b1;
disp('coef6...');
x0 = Otx + Rt*cos(Tht);
y0 = Oty + Rt*sin(Tht);
th1 = Tht;
nr = 8;
thp = 2*3.14159/nr;
Tht = thp*i1;
Rt = 20;
Otx = 8*r1;
torus1x = 0;
for i1 = 1:nr
  torus1x = torus1x + circle1x;
end
a1 = [Otx^4 Otx^3 Otx^2 Otx^1;];
b1 = [(eval(torus1x) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1);];
Otx = 64*r1;
torus1x = 0;
for i1 = 1:nr
  torus1x = torus1x + circle1x;
end
end
```

```
a1 = [a1; Otx^4 Otx^3 Otx^2 Otx^1;];
b1 = [b1; (eval(torus1x) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^
1);];
Otx = -8*r1;
torus1x = 0;
for i1 = 1:nr
   torus1x = torus1x + circle1x;
end
a1 = [a1; Otx^4 Otx^3 Otx^2 Otx^1;];
b1 = [b1; (eval(torus1x) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^
1);];
Otx = -64*r1;
torus1x = 0;
for i1 = 1:nr
   torus1x = torus1x + circle1x;
end
a1 = [a1; Otx^4 Otx^3 Otx^2 Otx^1;];
b1 = [b1; (eval(torus1x) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^
1);];

%;
%; The following is the first set of coefficients of the torus equation for Rt = 20, Otx =
variable
%;
coef7 = pinv(a1)*b1;
disp('coef7...');
x0 = Otx + Rt*cos(Tht);
y0 = Oty + Rt*sin(Tht);
th1 = Tht;
nr = 8;
thp = 2*3.14159/nr;
Tht = thp*i1;
Rt = 20;
Otx = 0;
Oty = 8*r1;
torus1x = 0;
for i1 = 1:nr
   torus1x = torus1x + circle1x;
end
a1 = [Oty^4 Oty^3 Oty^2 Oty^1;];
tmp = eval(torus1x) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
b1 = [tmp - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;];
Oty = 64*r1;
torus1x = 0;
for i1 = 1:nr
   torus1x = torus1x + circle1x;
end
a1 = [a1; Oty^4 Oty^3 Oty^2 Oty^1;];
tmp = eval(torus1x) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
b1 = [b1; tmp - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;];
Oty = -8*r1;
torus1x = 0;
for i1 = 1:nr
   torus1x = torus1x + circle1x;
end
a1 = [a1; Oty^4 Oty^3 Oty^2 Oty^1;];
tmp = eval(torus1x) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
b1 = [b1; tmp - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;];
Oty = -64*r1;
torus1x = 0;
for i1 = 1:nr
   torus1x = torus1x + circle1x;
end
a1 = [a1; Oty^4 Oty^3 Oty^2 Oty^1;];
tmp = eval(torus1x) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
b1 = [b1; tmp - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;];
```

```
%;
%; The following is the first set of coefficients of the torus equation for Rt = 20, Otx =
0, Oty = variable
%;
coef8 = pinv(a1)*b1;
disp('coef8...');
x0 = Otx + Rt*cos(Tht);
y0 = Oty + Rt*sin(Tht);
th1 = Tht;
nr = 8;
thp = 2*3.14159/nr;
Tht = thp*i1;
Rt = 20;
Otx = 0;
Oty = 0;
otz = 8*r1;
torus1x = 0;
for i1 = 1:nr
   torus1x = torus1x + circle1x;
end
a1 = [Otz^4 Otz^3 Otz^2 Otz^1;];
tmp = eval(torus1x) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
tmp = tmp - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;
b1 = [tmp - coef8(1)*Oty^4 - coef8(2)*Oty^3 - coef8(3)*Oty^2 - coef8(4)*Oty^1;];
Otz = 64*r1;
torus1x = 0;
for i1 = 1:nr
   torus1x = torus1x + circle1x;
end
a1 = [a1; Otz^4 Otz^3 Otz^2 Otz^1;];
tmp = eval(torus1x) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
tmp = tmp - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;
b1 = [b1; tmp - coef8(1)*Oty^4 - coef8(2)*Oty^3 - coef8(3)*Oty^2 - coef8(4)*Oty^1;];
Otz = -8*r1;
torus1x = 0;
for i1 = 1:nr
   torus1x = torus1x + circle1x;
end
a1 = [a1; Otz^4 Otz^3 Otz^2 Otz^1;];
tmp = eval(torus1x) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
tmp = tmp - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;
b1 = [b1; tmp - coef8(1)*Oty^4 - coef8(2)*Oty^3 - coef8(3)*Oty^2 - coef8(4)*Oty^1;];
Otz = -64*r1;
torus1x = 0;
for i1 = 1:nr
   torus1x = torus1x + circle1x;
end
a1 = [a1; Otz^4 Otz^3 Otz^2 Otz^1;];
tmp = eval(torus1x) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
tmp = tmp - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;
b1 = [b1; tmp - coef8(1)*Oty^4 - coef8(2)*Oty^3 - coef8(3)*Oty^2 - coef8(4)*Oty^1;];

%;
%; The following is the first set of coefficients of the torus equation for Rt = 20, Otx =
0, Oty = 0, Otz = var.
%;
coef9 = pinv(a1)*b1;
disp('coef9...');
%;
x0 = Otx + Rt*cos(Tht);
y0 = Oty + Rt*sin(Tht);
th1 = Tht;
nr = 8;
thp = 2*3.14159/nr;
Tht = thp*i1;
```

```
k1 = 10;
k2 = 2;
k3 = 2;
k4 = -2;
Rt = k1*r1;
Otx = k2*r1;
Oty = k3*r1;
Otz = k4*r1;
px1 = 2*r1;
torus1x = 0;
for i1 = 1:nr
   torus1x = torus1x + circle1x;
end
a1 = [px1^4 px1^3 px1^2 px1^1;];
tmp1 = eval(torus1x) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
tmp1 = tmp1 - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;
tmp1 = tmp1 - coef8(1)*Oty^4 - coef8(2)*Oty^3 - coef8(3)*Oty^2 - coef8(4)*Oty^1;
tmp1 = tmp1 - coef9(1)*Otz^4 - coef9(2)*Otz^3 - coef9(3)*Otz^2 - coef9(4)*Otz^1;

b1 = [tmp1;];
px1 = 8*r1;
torus1x = 0;
for i1 = 1:nr
   torus1x = torus1x + circle1x;
end
a1 = [a1; px1^4 px1^3 px1^2 px1^1;];
b1 = [b1; tmp1;];
px1 = 32*r1;
torus1x = 0;
for i1 = 1:nr
   torus1x = torus1x + circle1x;
end
a1 = [a1; px1^4 px1^3 px1^2 px1^1;];
b1 = [b1; tmp1;];
px1 = 200*r1;
torus1x = 0;
for i1 = 1:nr
   torus1x = torus1x + circle1x;
end
a1 = [a1; px1^4 px1^3 px1^2 px1^1;];
b1 = [b1; tmp1;];
%;
%; coefficients of the torus equation for (...) px1 = variable
%;
coef10 = pinv(a1)*b1;
disp('coef10...');

px1 = 2*r1;
py1 = 2*r1;
torus1x = 0;
for i1 = 1:nr
   torus1x = torus1x + circle1x;
end
a1 = [py1^4 py1^3 py1^2 py1^1;];
b1 = [tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;];
py1 = 8*r1;
torus1x = 0;
for i1 = 1:nr
   torus1x = torus1x + circle1x;
end
a1 = [a1; py1^4 py1^3 py1^2 py1^1;];
b1 = [b1; tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;];
py1 = 32*r1;
torus1x = 0;
for i1 = 1:nr
   torus1x = torus1x + circle1x;
```

```
end
a1 = [a1; py1^4 py1^3 py1^2 py1^1;];
b1 = [b1; tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;];
py1 = 200*r1;
torus1x = 0;
for i1 = 1:nr
   torus1x = torus1x + circle1x;
end
a1 = [a1; py1^4 py1^3 py1^2 py1^1;];
b1 = [b1; tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;];
%;
%; coefficients of the torus equation for (...) py1 = variable
%;
coef11 = pinv(a1)*b1;
disp('coef11...');
px1 = 2*r1;
py1 = 2*r1;
pz1 = 2*r1;
torus1x = 0;
for i1 = 1:nr
   torus1x = torus1x + circle1x;
end
a1 = [pz1^4 pz1^3 pz1^2 pz1^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
b1 = [tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;];
pz1 = 8*r1;
torus1x = 0;
for i1 = 1:nr
   torus1x = torus1x + circle1x;
end
a1 = [a1; pz1^4 pz1^3 pz1^2 pz1^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
b1 = [b1; tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;];
pz1 = 32*r1;
torus1x = 0;
for i1 = 1:nr
   torus1x = torus1x + circle1x;
end
a1 = [a1; pz1^4 pz1^3 pz1^2 pz1^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
b1 = [b1; tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;];
pz1 = 200*r1;
torus1x = 0;
for i1 = 1:nr
   torus1x = torus1x + circle1x;
end
a1 = [a1; pz1^4 pz1^3 pz1^2 pz1^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
b1 = [b1; tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;];

%;
%; coefficients of the torus equation for (...) pz1 = variable
%;
coef12 = pinv(a1)*b1;
disp('coef12...');
px1 = 2*r1;
py1 = 2*r1;
pz1 = 2*r1;
Tht = 3.14159/2;
torus1x = 0;
for i1 = 1:nr
   torus1x = torus1x + circle1x;
end
a1 = [Tht^4 Tht^3 Tht^2 Tht^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
tmp = tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;
```

```
b1 = [tmp - coef12(1)*pz1^4- coef12(2)*pz1^3 - coef12(3)*pz1^2 - coef12(4)*pz1^1;];
Tht = 3.14159;
torus1x = 0;
for i1 = 1:nr
   torus1x = torus1x + circle1x;
end
a1 = [a1; Tht^4 Tht^3 Tht^2 Tht^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
tmp = tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;
b1 = [b1; tmp - coef12(1)*pz1^4- coef12(2)*pz1^3 - coef12(3)*pz1^2 - coef12(4)*pz1^1;];
Tht = 3*3.14159/2;
torus1x = 0;
for i1 = 1:nr
   torus1x = torus1x + circle1x;
end
a1 = [a1; Tht^4 Tht^3 Tht^2 Tht^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
tmp =  tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;
b1 = [b1; tmp - coef12(1)*pz1^4- coef12(2)*pz1^3 - coef12(3)*pz1^2 - coef12(4)*pz1^1;];
Tht = 2*3.14159;
torus1x = 0;
for i1 = 1:nr
   torus1x = torus1x + circle1x;
end
a1 = [a1; Tht^4 Tht^3 Tht^2 Tht^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
tmp = tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;
b1 = [b1; tmp - coef12(1)*pz1^4- coef12(2)*pz1^3 - coef12(3)*pz1^2 - coef12(4)*pz1^1;];

%;
%; coefficients of the torus equation for (...) Tht = variable
%;
coef13 = pinv(a1)*b1;
disp('coef13...');
px1 = 2*r1;
py1 = 2*r1;
pz1 = 2*r1;
Tht = 0.0;
Thtn = 3.14159/2;
torus1x = 0;
for i1 = 1:nr
   torus1x = torus1x + circle1x;
end
a1 = [Thtn^4 Thtn^3 Thtn^2 Thtn^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
tmp = tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;
tmp = tmp - coef12(1)*pz1^4- coef12(2)*pz1^3 - coef12(3)*pz1^2 - coef12(4)*pz1^1;
b1 = [tmp - coef13(1)*Tht^4 - coef13(2)*Tht^3 - coef13(3)*Tht^2 - coef13(4)*Tht^1;];
Thtn = 3.14159;
torus1x = 0;
for i1 = 1:nr
   torus1x = torus1x + circle1x;
end
a1 = [a1; Thtn^4 Thtn^3 Thtn^2 Thtn^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
tmp = tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;
tmp = tmp - coef12(1)*pz1^4- coef12(2)*pz1^3 - coef12(3)*pz1^2 - coef12(4)*pz1^1;
b1 = [b1; tmp - coef13(1)*Tht^4 - coef13(2)*Tht^3 - coef13(3)*Tht^2 - coef13(4)*Tht^1;];
Thtn = 3*3.14159/2;
torus1x = 0;
for i1 = 1:nr
   torus1x = torus1x + circle1x;
end
a1 = [a1; Thtn^4 Thtn^3 Thtn^2 Thtn^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
tmp =  tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;
```

```
tmp =   tmp - coef12(1)*pz1^4- coef12(2)*pz1^3 - coef12(3)*pz1^2 - coef12(4)*pz1^1;
b1 = [b1; tmp - coef13(1)*Tht^4 - coef13(2)*Tht^3 - coef13(3)*Tht^2 - coef13(4)*Tht^1;];
Thtn = 2*3.14159;
torus1x = 0;
 or i1 = 1:nr
   torus1x = torus1x + circle1x;
end
a1 = [a1; Thtn^4 Thtn^3 Thtn^2 Thtn^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
tmp = tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;
tmp = tmp - coef12(1)*pz1^4- coef12(2)*pz1^3 - coef12(3)*pz1^2 - coef12(4)*pz1^1;
b1 = [b1; tmp - coef13(1)*Tht^4 - coef13(2)*Tht^3 - coef13(3)*Tht^2 - coef13(4)*Tht^1;];

%;
%; coefficients of the torus equation for (...) Thtn = variable
%;
coef14 = pinv(a1)*b1;
disp('coef14...');

%;
%; Now, finally the complete torus equation
%;

coef6 = eval(coef6);
coef7 = eval(coef7);
coef8 = eval(coef8);
coef9 = eval(coef9);
coef10 = eval(coef10);
coef11 = eval(coef11);
coef12 = eval(coef12);
coef13 = eval(coef13);
coef14 = eval(coef14);


 yms Rtt Otxt Otyt Otzt px1t py1t pz1t Thtt Thtnt;

toruseq1x = coef6(1)*Rtt^4 + coef6(2)*Rtt^3 + coef6(3)*Rtt^2 + coef6(4)*Rtt^1;
toruseq1x = toruseq1x + coef7(1)*Otxt^4 + coef7(2)*Otxt^3 + coef7(3)*Otxt^2 + coef7(4)
*Otxt^1;
toruseq1x = toruseq1x + coef8(1)*Otyt^4 + coef8(2)*Otyt^3 + coef8(3)*Otyt^2 + coef8(4)
*Otyt^1;
toruseq1x = toruseq1x + coef9(1)*Otzt^4 + coef9(2)*Otzt^3 + coef9(3)*Otzt^2 + coef9(4)
*Otzt^1;
toruseq1x = toruseq1x + coef10(1)*px1t^4 + coef10(2)*px1t^3 + coef10(3)*px1t^2 + coef10(4)
*px1t^1;
toruseq1x = toruseq1x + coef11(1)*py1t^4 + coef11(2)*py1t^3 + coef11(3)*py1t^2 + coef11(4)
*py1t^1;
toruseq1x = toruseq1x + coef12(1)*pz1t^4 + coef12(2)*pz1t^3 + coef12(3)*pz1t^2 + coef12(4)
*pz1t^1;
toruseq1x = toruseq1x + coef13(1)*Thtt^4 + coef13(2)*Thtt^3 + coef13(3)*Thtt^2 + coef13(4)
*Thtt^1;
toruseq1x = toruseq1x + coef14(1)*Thtnt^4 + coef14(2)*Thtnt^3 + coef14(3)*Thtnt^2 + coef14
(4)*Thtnt^1;
disp('finished computation of toruseq1x...');
fprintf(fid,'\n\ntoruseq1x = Sum of: \n');
for i1 = 1:4
  fprintf(fid,'%20.12f',coef6(i1));
  fprintf(fid,' Rtt^%1i',i1);
  fprintf(fid,'\n');
end
for i1 = 1:4
  fprintf(fid,'%20.12f',coef7(i1));
  fprintf(fid,' Otxt^%1i',i1);
  fprintf(fid,'\n');
end
for i1 = 1:4
  fprintf(fid,'%20.12f',coef8(i1));
```

```
      fprintf(fid,' Otyt^%li',i1);
      fprintf(fid,'\n');
   end
   for i1 = 1:4
      fprintf(fid,'%20.12f',coef9(i1));
      fprintf(fid,' Otzt^%li',i1);
      fprintf(fid,'\n');
   end
   for i1 = 1:4
      fprintf(fid,'%20.12f',coef10(i1));
      fprintf(fid,' px1t^%li',i1);
      fprintf(fid,'\n');
   end
   for i1 = 1:4
      fprintf(fid,'%20.12f',coef11(i1));
      fprintf(fid,' py1t^%li',i1);
      fprintf(fid,'\n');
   end
   for i1 = 1:4
      fprintf(fid,'%20.12f',coef12(i1));
      fprintf(fid,' pz1t^%li',i1);
      fprintf(fid,'\n');
   end
   for i1 = 1:4
      fprintf(fid,'%20.12f',coef13(i1));
      fprintf(fid,' Thtt^%li',i1);
      fprintf(fid,'\n');
   end
   for i1 = 1:4
      fprintf(fid,'%20.12f',coef14(i1));
      fprintf(fid,' Thtnt^%li',i1);
      fprintf(fid,'\n');
   end

   fprintf(fid,'\n\nTest of torus1x');
   Rtt = 5.0;
   Otxt = 0.0;
   Otyt = 0.0;
   Otzt = 0.0;
   px1t = 0.0;
   py1t = 0.0;
   pz1t = 0.0;
   Thtt = 0.0;
   Thtnt = 0.0;
   fprintf(fid,'\nRtt = %20.12f',Rtt);
   fprintf(fid,'\nOtx = %20.12f',Otxt);
   fprintf(fid,'\nOty = %20.12f',Otyt);
   fprintf(fid,'\nOtz = %20.12f',Otzt);
   fprintf(fid,'\npx1t = %20.12f',px1t);
   fprintf(fid,'\npy1t = %20.12f',py1t);
   fprintf(fid,'\npz1t = %20.12f',pz1t);
   fprintf(fid,'\nThtt = %20.12f',Thtt);
   fprintf(fid,'\nThtnt = %20.12f',Thtnt);
   fprintf(fid,'\ntorus1x = %20.12f',eval(torus1x));
   fprintf(fid,'\n');
   fprintf(fid,'\n\nTest of torus1x');
   Rtt = 5.0;
   Otxt = 0.0;
   Otyt = 0.0;
   Otzt = 0.0;
   px1t = 10.0;
   py1t = 0.0;
   pz1t = 0.0;
   Thtt = 0.0;
   Thtnt = 0.0;
   fprintf(fid,'\nRtt = %20.12f',Rtt);
```

```
fprintf(fid,'\nOtx = %20.12f',Otxt);
fprintf(fid,'\nOty = %20.12f',Otyt);
fprintf(fid,'\nOtz = %20.12f',Otzt);
fprintf(fid,'\npx1t = %20.12f',px1t);
fprintf(fid,'\npy1t = %20.12f',py1t);
fprintf(fid,'\npz1t = %20.12f',pz1t);
fprintf(fid,'\nThtt = %20.12f',Thtt);
fprintf(fid,'\nThtnt = %20.12f',Thtnt);
fprintf(fid,'\ntorus1x = %20.12f',eval(torus1x));
fprintf(fid,'\n');
fprintf(fid,'\n\nTest of torus1x');
Rtt = 5.0;
Otxt = 0.0;
Otyt = 0.0;
Otzt = 0.0;
px1t = 0.0;
py1t = 0.0;
pz1t = 10.0;
Thtt = 0.0;
Thtnt = 0.0;
fprintf(fid,'\nRtt = %20.12f',Rtt);
fprintf(fid,'\nOtx = %20.12f',Otxt);
fprintf(fid,'\nOty = %20.12f',Otyt);
fprintf(fid,'\nOtz = %20.12f',Otzt);
fprintf(fid,'\npx1t = %20.12f',px1t);
fprintf(fid,'\npy1t = %20.12f',py1t);
fprintf(fid,'\npz1t = %20.12f',pz1t);
fprintf(fid,'\nThtt = %20.12f',Thtt);
fprintf(fid,'\nThtnt = %20.12f',Thtnt);
fprintf(fid,'\ntorus1x = %20.12f',eval(torus1x));
fprintf(fid,'\n');
fprintf(fid,'\n\nTest of torus1x');
Rtt = 5.0;
Otxt = 0.0;
Otyt = 0.0;
Otzt = 0.0;
px1t = -10.0;
py1t = 0.0;
pz1t = 0.0;
Thtt = 0.0;
Thtnt = 0.0;
fprintf(fid,'\nRtt = %20.12f',Rtt);
fprintf(fid,'\nOtx = %20.12f',Otxt);
fprintf(fid,'\nOty = %20.12f',Otyt);
fprintf(fid,'\nOtz = %20.12f',Otzt);
fprintf(fid,'\npx1t = %20.12f',px1t);
fprintf(fid,'\npy1t = %20.12f',py1t);
fprintf(fid,'\npz1t = %20.12f',pz1t);
fprintf(fid,'\nThtt = %20.12f',Thtt);
fprintf(fid,'\nThtnt = %20.12f',Thtnt);
fprintf(fid,'\ntorus1x = %20.12f',eval(torus1x));
fprintf(fid,'\n');
fprintf(fid,'\n\nTest of torus1x');
Rtt = 5.0;
Otxt = 0.0;
Otyt = 0.0;
Otzt = 0.0;
px1t = 0.0;
py1t = 0.0;
pz1t = -10.0;
Thtt = 0.0;
Thtnt = 0.0;
fprintf(fid,'\nRtt = %20.12f',Rtt);
fprintf(fid,'\nOtx = %20.12f',Otxt);
fprintf(fid,'\nOty = %20.12f',Otyt);
fprintf(fid,'\nOtz = %20.12f',Otzt);
```

```matlab
fprintf(fid,'\npx1t = %20.12f',px1t);
fprintf(fid,'\npy1t = %20.12f',py1t);
fprintf(fid,'\npz1t = %20.12f',pz1t);
fprintf(fid,'\nThtt = %20.12f',Thtt);
fprintf(fid,'\nThtnt = %20.12f',Thtnt);
fprintf(fid,'\ntorus1x = %20.12f',eval(torus1x));
fprintf(fid,'\n');


syms coef6 coef7 coef8 coef9 coef10 coef11 coef12 coef13 coef14;


r1 = 1.0;
Otx = 0;
Oty = 0;
Otz = 0;
xpt = Otx + Rt*cos(Tht);
ypt = Oty + Rt*sin(Tht);
rpt = sqrt((xpt - Otx)^2 + (ypt - Oty)^2);
xt = xpt;
yt = ypt;
%; thpt = itan1(xt,yt);
syms thpt;
thcum = thpt + Thtn;
x0 = rpt*cos(thcum);
y0 = rpt*sin(thcum);
th1 = Tht;
th2 = 0;
nr = 8;
thp = 2*3.14159/nr;
Tht = thp*i1;
torus1y = 0;
Rt = 20;
for i1 = 1:nr
   thpt = itan1(xt,yt);
   torus1y = torus1y + circle1y;
end
a1 = [Rt^4 Rt^3 Rt^2 Rt^1;];
b1 = [eval(torus1x);];
Rt = 60;
for i1 = 1:nr
   thpt = itan1(xt,yt);
   torus1y = torus1y + circle1y;
end
a1 = [a1; Rt^4 Rt^3 Rt^2 Rt^1;];
b1 = [b1; eval(torus1y);];
Rt = 240;
for i1 = 1:nr
   thpt = itan1(xt,yt);
   torus1y = torus1y + circle1y;
end
a1 = [a1; Rt^4 Rt^3 Rt^2 Rt^2;];
b1 = [b1; eval(torus1y);];
Rt = 2400;
for i1 = 1:nr
   thpt = itan1(xt,yt);
   torus1y = torus1y + circle1y;
end
a1 = [a1; Rt^4 Rt^3 Rt^2 Rt^2;];
b1 = [b1; eval(torus1y);];
%;
%; The following is the first set of coefficients of the torus equation for Rt = variable
%;
coef6 = pinv(a1)*b1;
disp('coef6...');
x0 = Otx + Rt*cos(Tht);
```

```
y0 = Oty + Rt*sin(Tht);
th1 = Tht;
nr = 8;
thp = 2*3.14159/nr;
ht = thp*il;
Rt = 20;
Otx = 8*r1;
torusly = 0;
for il = 1:nr
  torusly = torusly + circlely;
end
a1 = [Otx^4 Otx^3 Otx^2 Otx^1;];
b1 = [(eval(torusly) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1);];
Otx = 64*r1;
torusly = 0;
for il = 1:nr
  torusly = torusly + circlely;
end
a1 = [a1; Otx^4 Otx^3 Otx^2 Otx^1;];
b1 = [b1; (eval(torusly) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^
1);];
Otx = -8*r1;
torusly = 0;
for il = 1:nr
  torusly = torusly + circlely;
end
a1 = [a1; Otx^4 Otx^3 Otx^2 Otx^1;];
b1 = [b1; (eval(torusly) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^
1);];
Otx = -64*r1;
torusly = 0;
for il = 1:nr
  torusly = torusly + circlely;
 nd
a1 = [a1; Otx^4 Otx^3 Otx^2 Otx^1;];
b1 = [b1; (eval(torusly) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^
1);];

%;
%; The following is the first set of coefficients of the torus equation for Rt = 20, Otx =
variable
%;
coef7 = pinv(a1)*b1;
disp('coef7...');
x0 = Otx + Rt*cos(Tht);
y0 = Oty + Rt*sin(Tht);
th1 = Tht;
nr = 8;
thp = 2*3.14159/nr;
Tht = thp*il;
Rt = 20;
Otx = 0;
Oty = 8*r1;
torusly = 0;
for il = 1:nr
  torusly = torusly + circlely;
end
a1 = [Oty^4 Oty^3 Oty^2 Oty^1;];
tmp = eval(torusly) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
b1 = [tmp - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;];
Oty = 64*r1;
torusly = 0;
for il = 1:nr
  torusly = torusly + circlely;
end
a1 = [a1; Oty^4 Oty^3 Oty^2 Oty^1;];
```

```
tmp = eval(torus1y) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
b1 = [b1; tmp - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;];
Oty = -8*r1;
torus1y = 0;
 or i1 = 1:nr
   torus1y = torus1y + circle1y;
end
a1 = [a1; Oty^4 Oty^3 Oty^2 Oty^1;];
tmp = eval(torus1y) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
b1 = [b1; tmp - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;];
Oty = -64*r1;
torus1y = 0;
for i1 = 1:nr
   torus1y = torus1y + circle1y;
end
a1 = [a1; Oty^4 Oty^3 Oty^2 Oty^1;];
tmp = eval(torus1y) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
b1 = [b1; tmp - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;];

%;
%; The following is the first set of coefficients of the torus equation for Rt = 20, Otx =
0, Oty = variable
%;
coef8 = pinv(a1)*b1;
disp('coef8...');
x0 = Otx + Rt*cos(Tht);
y0 = Oty + Rt*sin(Tht);
th1 = Tht;
nr = 8;
thp = 2*3.14159/nr;
Tht = thp*i1;
Rt = 20;
Otx = 0;
Oty = 0;
Otz = 8*r1;
torus1y = 0;
for i1 = 1:nr
   torus1y = torus1y + circle1y;
end
a1 = [Otz^4 Otz^3 Otz^2 Otz^1;];
tmp = eval(torus1y) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
tmp = tmp - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;
b1 = [tmp - coef8(1)*Oty^4 - coef8(2)*Oty^3 - coef8(3)*Oty^2 - coef8(4)*Oty^1;];
Otz = 64*r1;
torus1y = 0;
for i1 = 1:nr
   torus1y = torus1y + circle1y;
end
a1 = [a1; Otz^4 Otz^3 Otz^2 Otz^1;];
tmp = eval(torus1y) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
tmp = tmp - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;
b1 = [b1; tmp - coef8(1)*Oty^4 - coef8(2)*Oty^3 - coef8(3)*Oty^2 - coef8(4)*Oty^1;];
Otz = -8*r1;
torus1y = 0;
for i1 = 1:nr
   torus1y = torus1y + circle1y;
end
a1 = [a1; Otz^4 Otz^3 Otz^2 Otz^1;];
tmp = eval(torus1y) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
tmp = tmp - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;
b1 = [b1; tmp - coef8(1)*Oty^4 - coef8(2)*Oty^3 - coef8(3)*Oty^2 - coef8(4)*Oty^1;];
Otz = -64*r1;
torus1y = 0;
for i1 = 1:nr
   torus1y = torus1y + circle1y;
end
```

```
a1 = [a1; Otz^4 Otz^3 Otz^2 Otz^1;];
tmp = eval(torus1y) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
tmp = tmp - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;
b1 = [b1; tmp - coef8(1)*Oty^4 - coef8(2)*Oty^3 - coef8(3)*Oty^2 - coef8(4)*Oty^1;];
%;
%; The following is the first set of coefficients of the torus equation for Rt = 20, Otx =
0, Oty = 0, Otz = var.
%;
coef9 = pinv(a1)*b1;
disp('coef9...');
%;
x0 = Otx + Rt*cos(Tht);
y0 = Oty + Rt*sin(Tht);
th1 = Tht;
nr = 8;
thp = 2*3.14159/nr;
Tht = thp*i1;
Rt = k1*r1;
Otx = k2*r1;
Oty = k3*r1;
Otz = k4*r1;
px1 = 2*r1;
torus1y = 0;
for i1 = 1:nr
   torus1y = torus1y + circle1y;
end
a1 = [px1^4 px1^3 px1^2 px1^1;];
tmp1 = eval(torus1y) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
tmp1 = tmp1 - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;
tmp1 = tmp1 - coef8(1)*Oty^4 - coef8(2)*Oty^3 - coef8(3)*Oty^2 - coef8(4)*Oty^1;
tmp1 = tmp1 - coef9(1)*Otz^4 - coef9(2)*Otz^3 - coef9(3)*Otz^2 - coef9(4)*Otz^1;

 1 = [tmp1;];
px1 = 8*r1;
torus1y = 0;
for i1 = 1:nr
   torus1y = torus1y + circle1y;
end

a1 = [a1; px1^4 px1^3 px1^2 px1^1;];
b1 = [b1; tmp1;];
px1 = 32*r1;
torus1y = 0;
for i1 = 1:nr
   torus1y = torus1y + circle1y;
end
a1 = [a1; px1^4 px1^3 px1^2 px1^1;];
b1 = [b1; tmp1;];
px1 = 200*r1;
torus1y = 0;
for i1 = 1:nr
   torus1y = torus1y + circle1y;
end
a1 = [a1; px1^4 px1^3 px1^2 px1^1;];
b1 = [b1; tmp1;];
%;
%; coefficients of the torus equation for (...) px1 = variable
%;
coef10 = pinv(a1)*b1;
disp('coef10...');

px1 = 2*r1;
py1 = 2*r1;
torus1y = 0;
for i1 = 1:nr
```

```matlab
    torus1y = torus1y + circle1y;
  end
  a1 = [py1^4 py1^3 py1^2 py1^1;];
  b1 = [tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;];
  py1 = 8*r1;
  torus1y = 0;
  for i1 = 1:nr
    torus1y = torus1y + circle1y;
  end
  a1 = [a1; py1^4 py1^3 py1^2 py1^1;];
  b1 = [b1; tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;];
  py1 = 32*r1;
  torus1y = 0;
  for i1 = 1:nr
    torus1y = torus1y + circle1y;
  end
  a1 = [a1; py1^4 py1^3 py1^2 py1^1;];
  b1 = [b1; tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;];
  py1 = 200*r1;
  torus1y = 0;
  for i1 = 1:nr
    torus1y = torus1y + circle1y;
  end
  a1 = [a1; py1^4 py1^3 py1^2 py1^1;];
  b1 = [b1; tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;];
%;
%; coefficients of the torus equation for (...) py1 = variable
%;
  coef11 = pinv(a1)*b1;
  disp('coef11...');
  px1 = 2*r1;
  py1 = 2*r1;
  pz1 = 2*r1;
  torus1y = 0;
  for i1 = 1:nr
    torus1y = torus1y + circle1y;
  end
  a1 = [pz1^4 pz1^3 pz1^2 pz1^1;];
  tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
  b1 = [tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;];
  pz1 = 8*r1;
  torus1y = 0;
  for i1 = 1:nr
    torus1y = torus1y + circle1y;
  end
  a1 = [a1; pz1^4 pz1^3 pz1^2 pz1^1;];
  tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
  b1 = [b1; tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;];
  pz1 = 32*r1;
  torus1y = 0;
  for i1 = 1:nr
    torus1y = torus1y + circle1y;
  end
  a1 = [a1; pz1^4 pz1^3 pz1^2 pz1^1;];
  tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
  b1 = [b1; tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;];
  pz1 = 200*r1;
  torus1y = 0;
  for i1 = 1:nr
    torus1y = torus1y + circle1y;
  end
  a1 = [a1; pz1^4 pz1^3 pz1^2 pz1^1;];
  tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
  b1 = [b1; tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;];

%;
```

```
%; coefficients of the torus equation for (...) pz1 = variable
%;
coef12 = pinv(a1)*b1;
disp('coef12...');
px1 = 2*r1;
py1 = 2*r1;
pz1 = 2*r1;
Tht = 3.14159/2;
torus1y = 0;
for i1 = 1:nr
   torus1y = torus1y + circle1y;
end
a1 = [Tht^4 Tht^3 Tht^2 Tht^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
tmp = tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;
b1 = [tmp - coef12(1)*pz1^4- coef12(2)*pz1^3 - coef12(3)*pz1^2 - coef12(4)*pz1^1;];
Tht = 3.14159;
torus1y = 0;
for i1 = 1:nr
   torus1y = torus1y + circle1y;
end
a1 = [a1; Tht^4 Tht^3 Tht^2 Tht^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
tmp = tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;
b1 = [b1; tmp - coef12(1)*pz1^4- coef12(2)*pz1^3 - coef12(3)*pz1^2 - coef12(4)*pz1^1;];
Tht = 3*3.14159/2;
torus1y = 0;
for i1 = 1:nr
   torus1y = torus1y + circle1y;
end
a1 = [a1; Tht^4 Tht^3 Tht^2 Tht^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
tmp =   tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;
b1 = [b1; tmp - coef12(1)*pz1^4- coef12(2)*pz1^3 - coef12(3)*pz1^2 - coef12(4)*pz1^1;];
Tht = 2*3.14159;
torus1y = 0;
for i1 = 1:nr
   torus1y = torus1y + circle1y;
end
a1 = [a1; Tht^4 Tht^3 Tht^2 Tht^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
tmp = tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;
b1 = [b1; tmp - coef12(1)*pz1^4- coef12(2)*pz1^3 - coef12(3)*pz1^2 - coef12(4)*pz1^1;];

%;
%; coefficients of the torus equation for (...) Tht = variable
%;
coef13 = pinv(a1)*b1;
disp('coef13...');
px1 = 2*r1;
py1 = 2*r1;
pz1 = 2*r1;
Tht = 0.0;
Thtn = 3.14159/2;
torus1y = 0;
for i1 = 1:nr
   torus1y = torus1y + circle1y;
end
a1 = [Thtn^4 Thtn^3 Thtn^2 Thtn^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
tmp = tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;
tmp = tmp - coef12(1)*pz1^4- coef12(2)*pz1^3 - coef12(3)*pz1^2 - coef12(4)*pz1^1;
b1 = [tmp - coef13(1)*Tht^4 - coef13(2)*Tht^3 - coef13(3)*Tht^2 - coef13(4)*Tht^1;];
Thtn = 3.14159;
torus1y = 0;
for i1 = 1:nr
```

```
      torus1y = torus1y + circle1y;
   end
   a1 = [a1; Thtn^4 Thtn^3 Thtn^2 Thtn^1;];
   tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
   tmp = tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;
   tmp = tmp - coef12(1)*pz1^4- coef12(2)*pz1^3 - coef12(3)*pz1^2 - coef12(4)*pz1^1;
   b1 = [b1; tmp - coef13(1)*Tht^4 - coef13(2)*Tht^3 - coef13(3)*Tht^2 - coef13(4)*Tht^1;];
   Thtn = 3*3.14159/2;
   torus1y = 0;
   for i1 = 1:nr
      torus1y = torus1y + circle1y;
   end
   a1 = [a1; Thtn^4 Thtn^3 Thtn^2 Thtn^1;];
   tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
   tmp =   tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;
   tmp =   tmp - coef12(1)*pz1^4- coef12(2)*pz1^3 - coef12(3)*pz1^2 - coef12(4)*pz1^1;
   b1 = [b1; tmp - coef13(1)*Tht^4 - coef13(2)*Tht^3 - coef13(3)*Tht^2 - coef13(4)*Tht^1;];
   Thtn = 2*3.14159;
   torus1y = 0;
   for i1 = 1:nr
      torus1y = torus1y + circle1y;
   end
   a1 = [a1; Thtn^4 Thtn^3 Thtn^2 Thtn^1;];
   tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
   tmp = tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;
   tmp = tmp - coef12(1)*pz1^4- coef12(2)*pz1^3 - coef12(3)*pz1^2 - coef12(4)*pz1^1;
   b1 = [b1; tmp - coef13(1)*Tht^4 - coef13(2)*Tht^3 - coef13(3)*Tht^2 - coef13(4)*Tht^1;];

%;
%; coefficients of the torus equation for (...) Thtn = variable
%;
coef14 = pinv(a1)*b1;
disp('coef14...');


%;
%; Now, finally the complete torus equation
%;

%;coef6 = eval(coef6);
%;coef7 = eval(coef7);
%;coef8 = eval(coef8);
%;coef9 = eval(coef9);
%;coef10 = eval(coef10);
%;coef11 = eval(coef11);
%;coef12 = eval(coef12);
%;coef13 = eval(coef13);
%;coef14 = eval(coef14);


syms Rtt Otxt Otyt Otzt px1t py1t pz1t thtt Thtnt;

toruseq1y = coef6(1)*Rtt^4 + coef6(2)*Rtt^3 + coef6(3)*Rtt^2 + coef6(4)*Rtt^1;
toruseq1y = toruseq1y + coef7(1)*Otxt^4 + coef7(2)*Otxt^3 + coef7(3)*Otxt^2 + coef7(4)
*Otxt^1;
toruseq1y = toruseq1y + coef8(1)*Otyt^4 + coef8(2)*Otyt^3 + coef8(3)*Otyt^2 + coef8(4)
*Otyt^1;
toruseq1y = toruseq1y + coef9(1)*Otzt^4 + coef9(2)*Otzt^3 + coef9(3)*Otzt^2 + coef9(4)
*Otzt^1;
toruseq1y = toruseq1y + coef10(1)*px1t^4 + coef10(2)*px1t^3 + coef10(3)*px1t^2 + coef10(4)
*px1t^1;
toruseq1y = toruseq1y + coef11(1)*py1t^4 + coef11(2)*py1t^3 + coef11(3)*py1t^2 + coef11(4)
*py1t^1;
toruseq1y = toruseq1y + coef12(1)*pz1t^4 + coef12(2)*pz1t^3 + coef12(3)*pz1t^2 + coef12(4)
*pz1t^1;
toruseq1y = toruseq1y + coef13(1)*Thtt^4 + coef13(2)*Thtt^3 + coef13(3)*Thtt^2 + coef13(4)
*Thtt^1;
toruseq1y = toruseq1y + coef14(1)*Thtnt^4 + coef14(2)*Thtnt^3 + coef14(3)*Thtnt^2 + coef14
```

```
(4)*Thtnt^1;
disp('finished computation of toruseq1y...');
fprintf(fid,'\n\ntoruseq1y = Sum of: \n');
for i1 = 1:4
   fprintf(fid,'%20.12f',coef6(i1));
   fprintf(fid,' Rtt^%1i',i1);
   fprintf(fid,'\n');
end
for i1 = 1:4
   fprintf(fid,'%20.12f',coef7(i1));
   fprintf(fid,' Otxt^%1i',i1);
   fprintf(fid,'\n');
end
for i1 = 1:4
   fprintf(fid,'%20.12f',coef8(i1));
   fprintf(fid,' Otyt^%1i',i1);
   fprintf(fid,'\n');
end
for i1 = 1:4
   fprintf(fid,'%20.12f',coef9(i1));
   fprintf(fid,' Otzt^%1i',i1);
   fprintf(fid,'\n');
end
for i1 = 1:4
   fprintf(fid,'%20.12f',coef10(i1));
   fprintf(fid,' px1t^%1i',i1);
   fprintf(fid,'\n');
end
for i1 = 1:4
   fprintf(fid,'%20.12f',coef11(i1));
   fprintf(fid,' py1t^%1i',i1);
   fprintf(fid,'\n');
end
for i1 = 1:4
   fprintf(fid,'%20.12f',coef12(i1));
   fprintf(fid,' pz1t^%1i',i1);
   fprintf(fid,'\n');
end
for i1 = 1:4
   fprintf(fid,'%20.12f',coef13(i1));
   fprintf(fid,' Thtt^%1i',i1);
   fprintf(fid,'\n');
end
for i1 = 1:4
   fprintf(fid,'%20.12f',coef14(i1));
   fprintf(fid,' Thtnt^%1i',i1);
   fprintf(fid,'\n');
end

fprintf(fid,'\n\nTest of torus1y');
Rtt = 5.0;
Otxt = 0.0;
Otyt = 0.0;
Otzt = 0.0;
px1t = 0.0;
py1t = 0.0;
pz1t = 0.0;
Thtt = 0.0;
Thtnt = 0.0;
fprintf(fid,'\nRtt = %20.12f',Rtt);
fprintf(fid,'\nOtx = %20.12f',Otxt);
fprintf(fid,'\nOty = %20.12f',Otyt);
fprintf(fid,'\nOtz = %20.12f',Otzt);
fprintf(fid,'\npx1t = %20.12f',px1t);
fprintf(fid,'\npy1t = %20.12f',py1t);
fprintf(fid,'\npz1t = %20.12f',pz1t);
```

```
fprintf(fid,'\nThtt = %20.12f',Thtt);
fprintf(fid,'\nThtnt = %20.12f',Thtnt);
fprintf(fid,'\ntorus1y = %20.12f',eval(torus1y));
fprintf(fid,'\n');
fprintf(fid,'\n\nTest of torus1y');
Rtt = 5.0;
Otxt = 0.0;
Otyt = 0.0;
Otzt = 0.0;
px1t = 10.0;
py1t = 0.0;
pz1t = 0.0;
Thtt = 0.0;
Thtnt = 0.0;
fprintf(fid,'\nRtt = %20.12f',Rtt);
fprintf(fid,'\nOtx = %20.12f',Otxt);
fprintf(fid,'\nOty = %20.12f',Otyt);
fprintf(fid,'\nOtz = %20.12f',Otzt);
fprintf(fid,'\npx1t = %20.12f',px1t);
fprintf(fid,'\npy1t = %20.12f',py1t);
fprintf(fid,'\npz1t = %20.12f',pz1t);
fprintf(fid,'\nThtt = %20.12f',Thtt);
fprintf(fid,'\nThtnt = %20.12f',Thtnt);
fprintf(fid,'\ntorus1y = %20.12f',eval(torus1y));
fprintf(fid,'\n');
fprintf(fid,'\n\nTest of torus1y');
Rtt = 5.0;
Otxt = 0.0;
Otyt = 0.0;
Otzt = 0.0;
px1t = 0.0;
py1t = 0.0;
pz1t = 10.0;
Thtt = 0.0;
Thtnt = 0.0;
fprintf(fid,'\nRtt = %20.12f',Rtt);
fprintf(fid,'\nOtx = %20.12f',Otxt);
fprintf(fid,'\nOty = %20.12f',Otyt);
fprintf(fid,'\nOtz = %20.12f',Otzt);
fprintf(fid,'\npx1t = %20.12f',px1t);
fprintf(fid,'\npy1t = %20.12f',py1t);
fprintf(fid,'\npz1t = %20.12f',pz1t);
fprintf(fid,'\nThtt = %20.12f',Thtt);
fprintf(fid,'\nThtnt = %20.12f',Thtnt);
fprintf(fid,'\ntorus1y = %20.12f',eval(torus1y));
fprintf(fid,'\n');
fprintf(fid,'\n\nTest of torus1y');
Rtt = 5.0;
Otxt = 0.0;
Otyt = 0.0;
Otzt = 0.0;
px1t = -10.0;
py1t = 0.0;
pz1t = 0.0;
Thtt = 0.0;
Thtnt = 0.0;
fprintf(fid,'\nRtt = %20.12f',Rtt);
fprintf(fid,'\nOtx = %20.12f',Otxt);
fprintf(fid,'\nOty = %20.12f',Otyt);
fprintf(fid,'\nOtz = %20.12f',Otzt);
fprintf(fid,'\npx1t = %20.12f',px1t);
fprintf(fid,'\npy1t = %20.12f',py1t);
fprintf(fid,'\npz1t = %20.12f',pz1t);
fprintf(fid,'\nThtt = %20.12f',Thtt);
fprintf(fid,'\nThtnt = %20.12f',Thtnt);
fprintf(fid,'\ntorus1y = %20.12f',eval(torus1y));
```

```
fprintf(fid,'\n');
fprintf(fid,'\n\nTest of torus1y');
Rtt = 5.0;
Otxt = 0.0;
Otyt = 0.0;
Otzt = 0.0;
px1t = 0.0;
py1t = 0.0;
pz1t = -10.0;
Thtt = 0.0;
Thtnt = 0.0;
fprintf(fid,'\nRtt = %20.12f',Rtt);
fprintf(fid,'\nOtx = %20.12f',Otxt);
fprintf(fid,'\nOty = %20.12f',Otyt);
fprintf(fid,'\nOtz = %20.12f',Otzt);
fprintf(fid,'\npx1t = %20.12f',px1t);
fprintf(fid,'\npy1t = %20.12f',py1t);
fprintf(fid,'\npz1t = %20.12f',pz1t);
fprintf(fid,'\nThtt = %20.12f',Thtt);
fprintf(fid,'\nThtnt = %20.12f',Thtnt);
fprintf(fid,'\ntorus1y = %20.12f',eval(torus1y));
fprintf(fid,'\n');

syms coef6 coef7 coef8 coef9 coef10 coef11 coef12 coef13 coef14;

r1 = 1.0;
Otx = 0;
Oty = 0;
Otz = 0;
xpt = Otx + Rt*cos(Tht);
ypt = Oty + Rt*sin(Tht);
rpt = sqrt((xpt - Otx)^2 + (ypt - Oty)^2);
xt = xpt;
yt = ypt;
%; thpt = itan1(xt,yt);
syms thpt;
thcum = thpt + Thtn;
x0 = rpt*cos(thcum);
y0 = rpt*sin(thcum);
th1 = Tht;
th2 = 0;
nr = 8;
thp = 2*3.14159/nr;
Tht = thp*i1;
Rt = 20;
torus1z = 0;
for i1 = 1:nr
   thpt = itan1(xt,yt);
   torus1z = torus1z + circle1z;
end
a1 = [Rt^4 Rt^3 Rt^2 Rt^1;];
b1 = [eval(torus1z);];
Rt = 60;
torus1z = 0;
for i1 = 1:nr
   thpt = itan1(xt,yt);
   torus1z = torus1z + circle1z;
end
a1 = [a1; Rt^4 Rt^3 Rt^2 Rt^1;];
b1 = [b1; eval(torus1z);];
Rt = 240;
torus1z = 0;
for i1 = 1:nr
   thpt = itan1(xt,yt);
   torus1z = torus1z + circle1z;
end
```

```matlab
a1 = [a1; Rt^4 Rt^3 Rt^2 Rt^2;];
b1 = [b1; eval(torus1z);];
Rt = 2400;
torus1z = 0;
for i1 = 1:nr
  thpt = itan1(xt,yt);
  torus1z = torus1z + circle1z;
end
a1 = [a1; Rt^4 Rt^3 Rt^2 Rt^2;];
b1 = [b1; eval(torus1z);];
%;
%; The following is the first set of coefficients of the torus equation for Rt = variable
%;
coef6 = pinv(a1)*b1;
disp('coef6...');
x0 = Otx + Rt*cos(Tht);
y0 = Oty + Rt*sin(Tht);
th1 = Tht;
nr = 8;
thp = 2*3.14159/nr;
Tht = thp*i1;
Rt = 20;
Otx = 8*r1;
torus1z = 0;
for i1 = 1:nr
  torus1z = torus1z + circle1z;
end
a1 = [Otx^4 Otx^3 Otx^2 Otx^1;];
b1 = [(eval(torus1z) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1);];
Otx = 64*r1;
torus1z = 0;
for i1 = 1:nr
  torus1z = torus1z + circle1z;
 nd
a1 = [a1; Otx^4 Otx^3 Otx^2 Otx^1;];
b1 = [b1; (eval(torus1z) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^
1);];
Otx = -8*r1;
torus1z = 0;
for i1 = 1:nr
  torus1z = torus1z + circle1z;
end
a1 = [a1; Otx^4 Otx^3 Otx^2 Otx^1;];
b1 = [b1; (eval(torus1z) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^
1);];
Otx = -64*r1;
torus1z = 0;
for i1 = 1:nr
  torus1z = torus1z + circle1z;
end
a1 = [a1; Otx^4 Otx^3 Otx^2 Otx^1;];
b1 = [b1; (eval(torus1z) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^
1);];

%;
%; The following is the first set of coefficients of the torus equation for Rt = 20, Otx =
variable
%;
coef7 = pinv(a1)*b1;
disp('coef7...');
x0 = Otx + Rt*cos(Tht);
0 = Oty + Rt*sin(Tht);
th1 = Tht;
nr = 8;
thp = 2*3.14159/nr;
Tht = thp*i1;
```

```
Rt = 20;
Otx = 0;
Oty = 8*r1;
torus1z = 0;
for i1 = 1:nr
  torus1z = torus1z + circle1z;
end
a1 = [Oty^4 Oty^3 Oty^2 Oty^1;];
tmp = eval(torus1z) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
b1 = [tmp - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;];
Oty = 64*r1;
torus1z = 0;
for i1 = 1:nr
  torus1z = torus1z + circle1z;
end
a1 = [a1; Oty^4 Oty^3 Oty^2 Oty^1;];
tmp = eval(torus1z) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
b1 = [b1; tmp - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;];
Oty = -8*r1;
torus1z = 0;
for i1 = 1:nr
  torus1z = torus1z + circle1z;
end
a1 = [a1; Oty^4 Oty^3 Oty^2 Oty^1;];
tmp = eval(torus1z) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
b1 = [b1; tmp - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;];
Oty = -64*r1;
torus1z = 0;
for i1 = 1:nr
  torus1z = torus1z + circle1z;
end
a1 = [a1; Oty^4 Oty^3 Oty^2 Oty^1;];
tmp = eval(torus1z) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
b1 = [b1; tmp - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;];

%;
%; The following is the first set of coefficients of the torus equation for Rt = 20, Otx =
0, Oty = variable
%;
coef8 = pinv(a1)*b1;
disp('coef8...');
x0 = Otx + Rt*cos(Tht);
y0 = Oty + Rt*sin(Tht);
th1 = Tht;
nr = 8;
thp = 2*3.14159/nr;
Tht = thp*i1;
Rt = 20;
Otx = 0;
Oty = 0;
Otz = 8*r1;
torus1z = 0;
for i1 = 1:nr
  torus1z = torus1z + circle1z;
end
a1 = [Otz^4 Otz^3 Otz^2 Otz^1;];
tmp = eval(torus1z) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
tmp = tmp - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;
b1 = [tmp - coef8(1)*Oty^4 - coef8(2)*Oty^3 - coef8(3)*Oty^2 - coef8(4)*Oty^1;];
Otz = 64*r1;
torus1z = 0;
for i1 = 1:nr
  torus1z = torus1z + circle1z;
end
a1 = [a1; Otz^4 Otz^3 Otz^2 Otz^1;];
tmp = eval(torus1z) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
```

```
tmp = tmp - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;
b1 = [b1; tmp - coef8(1)*Oty^4 - coef8(2)*Oty^3 - coef8(3)*Oty^2 - coef8(4)*Oty^1;];
Otz = -8*r1;
torus1z = 0;
for i1 = 1:nr
    torus1z = torus1z + circle1z;
end
a1 = [a1; Otz^4 Otz^3 Otz^2 Otz^1;];
tmp = eval(torus1z) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
tmp = tmp - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;
b1 = [b1; tmp - coef8(1)*Oty^4 - coef8(2)*Oty^3 - coef8(3)*Oty^2 - coef8(4)*Oty^1;];
Otz = -64*r1;
torus1z = 0;
for i1 = 1:nr
    torus1z = torus1z + circle1z;
end
a1 = [a1; Otz^4 Otz^3 Otz^2 Otz^1;];
tmp = eval(torus1z) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
tmp = tmp - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;
b1 = [b1; tmp - coef8(1)*Oty^4 - coef8(2)*Oty^3 - coef8(3)*Oty^2 - coef8(4)*Oty^1;];

%;
%; The following is the first set of coefficients of the torus equation for Rt = 20, Otx =
0, Oty = 0, Otz = var.
%;
coef9 = pinv(a1)*b1;
disp('coef9...');
%;
x0 = Otx + Rt*cos(Tht);
y0 = Oty + Rt*sin(Tht);
th1 = Tht;
nr = 8;
thp = 2*3.14159/nr;
tht = thp*i1;
Rt = k1*r1;
Otx = k2*r1;
Oty = k3*r1;
Otz = k4*r1;
px1 = 2*r1;
torus1z = 0;
for i1 = 1:nr
    torus1z = torus1z + circle1z;
end
a1 = [px1^4 px1^3 px1^2 px1^1;];
tmp1 = eval(torus1z) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
tmp1 = tmp1 - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;
tmp1 = tmp1 - coef8(1)*Oty^4 - coef8(2)*Oty^3 - coef8(3)*Oty^2 - coef8(4)*Oty^1;
tmp1 = tmp1 - coef9(1)*Otz^4 - coef9(2)*Otz^3 - coef9(3)*Otz^2 - coef9(4)*Otz^1;

b1 = [tmp1;];
px1 = 8*r1;
torus1z = 0;
for i1 = 1:nr
    torus1z = torus1z + circle1z;
end
a1 = [a1; px1^4 px1^3 px1^2 px1^1;];
b1 = [b1; tmp1;];
px1 = 32*r1;
torus1z = 0;
for i1 = 1:nr
    torus1z = torus1z + circle1z;
end
a1 = [a1; px1^4 px1^3 px1^2 px1^1;];
b1 = [b1; tmp1;];
px1 = 200*r1;
torus1z = 0;
```

```
  for i1 = 1:nr
    torus1z = torus1z + circle1z;
  end
  a1 = [a1; px1^4 px1^3 px1^2 px1^1;];
  b1 = [b1; tmp1;];
  %;
  %; coefficients of the torus equation for (...) px1 = variable
  %;
  coef10 = pinv(a1)*b1;
  disp('coef10...');

  px1 = 2*r1;
  py1 = 2*r1;
  torus1z = 0;
  for i1 = 1:nr
    torus1z = torus1z + circle1z;
  end
  a1 = [py1^4 py1^3 py1^2 py1^1;];
  b1 = [tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;];
  py1 = 8*r1;
  torus1z = 0;
  for i1 = 1:nr
    torus1z = torus1z + circle1z;
  end
  a1 = [a1; py1^4 py1^3 py1^2 py1^1;];
  b1 = [b1; tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;];
  py1 = 32*r1;
  torus1z = 0;
  for i1 = 1:nr
    torus1z = torus1z + circle1z;
  end
  a1 = [a1; py1^4 py1^3 py1^2 py1^1;];
  b1 = [b1; tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;];
  py1 = 200*r1;
  torus1z = 0;
  for i1 = 1:nr
    torus1z = torus1z + circle1z;
  end
  a1 = [a1; py1^4 py1^3 py1^2 py1^1;];
  b1 = [b1; tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;];
  %;
  %; coefficients of the torus equation for (...) py1 = variable
  %;
  coef11 = pinv(a1)*b1;
  disp('coef11...');
  px1 = 2*r1;
  py1 = 2*r1;
  pz1 = 2*r1;
  torus1z = 0;
  for i1 = 1:nr
    torus1z = torus1z + circle1z;
  end
  a1 = [pz1^4 pz1^3 pz1^2 pz1^1;];
  tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
  b1 = [tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;];
  pz1 = 8*r1;
  torus1z = 0;
  for i1 = 1:nr
    torus1z = torus1z + circle1z;
  end
  a1 = [a1; pz1^4 pz1^3 pz1^2 pz1^1;];
  tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
  b1 = [b1; tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;];
  pz1 = 32*r1;
  torus1z = 0;
  for i1 = 1:nr
```

```
    torus1z = torus1z + circle1z;
  end
  a1 = [a1; pz1^4 pz1^3 pz1^2 pz1^1;];
  tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
  b1 = [b1; tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;];
  pz1 = 200*r1;
  torus1z = 0;
  for i1 = 1:nr
    torus1z = torus1z + circle1z;
  end
  a1 = [a1; pz1^4 pz1^3 pz1^2 pz1^1;];
  tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
  b1 = [b1; tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;];

  %;
  %; coefficients of the torus equation for (...) pz1 = variable
  %;
  coef12 = pinv(a1)*b1;
  disp('coef12...');
  px1 = 2*r1;
  py1 = 2*r1;
  pz1 = 2*r1;
  Tht = 3.14159/2;
  torus1z = 0;
  for i1 = 1:nr
    torus1z = torus1z + circle1z;
  end
  a1 = [Tht^4 Tht^3 Tht^2 Tht^1;];
  tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
  tmp = tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;
  b1 = [tmp - coef12(1)*pz1^4 - coef12(2)*pz1^3 - coef12(3)*pz1^2 - coef12(4)*pz1^1;];
  Tht = 3.14159;
  torus1z = 0;
  for i1 = 1:nr
    torus1z = torus1z + circle1z;
  end
  a1 = [a1; Tht^4 Tht^3 Tht^2 Tht^1;];
  tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
  tmp = tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;
  b1 = [b1; tmp - coef12(1)*pz1^4- coef12(2)*pz1^3 - coef12(3)*pz1^2 - coef12(4)*pz1^1;];
  Tht = 3*3.14159/2;
  torus1z = 0;
  for i1 = 1:nr
    torus1z = torus1z + circle1z;
  end
  a1 = [a1; Tht^4 Tht^3 Tht^2 Tht^1;];
  tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
  tmp =  tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;
  b1 = [b1; tmp - coef12(1)*pz1^4- coef12(2)*pz1^3 - coef12(3)*pz1^2 - coef12(4)*pz1^1;];
  Tht = 2*3.14159;
  torus1z = 0;
  for i1 = 1:nr
    torus1z = torus1z + circle1z;
  end
  a1 = [a1; Tht^4 Tht^3 Tht^2 Tht^1;];
  tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
  tmp = tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;
  b1 = [b1; tmp - coef12(1)*pz1^4- coef12(2)*pz1^3 - coef12(3)*pz1^2 - coef12(4)*pz1^1;];

  %;
  %; coefficients of the torus equation for (...) Tht = variable
  %;
  coef13 = pinv(a1)*b1;
  disp('coef13...');
  px1 = 2*r1;
  py1 = 2*r1;
```

```
pz1 = 2*r1;
Tht = 0.0;
Thtn = 3.14159/2;
torus1z = 0;
for i1 = 1:nr
    torus1z = torus1z + circle1z;
end
a1 = [Thtn^4 Thtn^3 Thtn^2 Thtn^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
tmp = tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;
tmp = tmp - coef12(1)*pz1^4- coef12(2)*pz1^3 - coef12(3)*pz1^2 - coef12(4)*pz1^1;
b1 = [tmp - coef13(1)*Tht^4 - coef13(2)*Tht^3 - coef13(3)*Tht^2 - coef13(4)*Tht^1;];
Thtn = 3.14159;
torus1z = 0;
for i1 = 1:nr
    torus1z = torus1z + circle1z;
end
a1 = [a1; Thtn^4 Thtn^3 Thtn^2 Thtn^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
tmp = tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;
tmp = tmp - coef12(1)*pz1^4- coef12(2)*pz1^3 - coef12(3)*pz1^2 - coef12(4)*pz1^1;
b1 = [b1; tmp - coef13(1)*Tht^4 - coef13(2)*Tht^3 - coef13(3)*Tht^2 - coef13(4)*Tht^1;];
Thtn = 3*3.14159/2;
torus1z = 0;
for i1 = 1:nr
    torus1z = torus1z + circle1z;
end
a1 = [a1; Thtn^4 Thtn^3 Thtn^2 Thtn^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
tmp =  tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;
tmp =  tmp - coef12(1)*pz1^4- coef12(2)*pz1^3 - coef12(3)*pz1^2 - coef12(4)*pz1^1;
b1 = [b1; tmp - coef13(1)*Tht^4 - coef13(2)*Tht^3 - coef13(3)*Tht^2 - coef13(4)*Tht^1;];
Thtn = 2*3.14159;
torus1z = 0;
for i1 = 1:nr
    torus1z = torus1z + circle1z;
end
a1 = [a1; Thtn^4 Thtn^3 Thtn^2 Thtn^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
tmp = tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;
tmp = tmp - coef12(1)*pz1^4- coef12(2)*pz1^3 - coef12(3)*pz1^2 - coef12(4)*pz1^1;
b1 = [b1; tmp - coef13(1)*Tht^4 - coef13(2)*Tht^3 - coef13(3)*Tht^2 - coef13(4)*Tht^1;];

%;
%; coefficients of the torus equation for (...) Thtn = variable
%;
coef14 = pinv(a1)*b1;
disp('coef14...');

%;
%; Now, finally the complete torus equation
%;

%;coef6 = eval(coef6);
%;coef7 = eval(coef7);
%;coef8 = eval(coef8);
%;coef9 = eval(coef9);
%;coef10 = eval(coef10);
%;coef11 = eval(coef11);
%;coef12 = eval(coef12);
%;coef13 = eval(coef13);
%;coef14 = eval(coef14);

syms Rtt Otxt Otyt Otzt px1t py1t pz1t Thtt Thtnt;

toruseq1z = coef6(1)*Rtt^4 + coef6(2)*Rtt^3 + coef6(3)*Rtt^2 + coef6(4)*Rtt^1;
```

```
toruseq1z = toruseq1z + coef7(1)*Otxt^4 + coef7(2)*Otxt^3 + coef7(3)*Otxt^2 + coef7(4)
*Otxt^1;
toruseq1z = toruseq1z + coef8(1)*Otyt^4 + coef8(2)*Otyt^3 + coef8(3)*Otyt^2 + coef8(4)
*Otyt^1;
 oruseq1z = toruseq1z + coef9(1)*Otzt^4 + coef9(2)*Otzt^3 + coef9(3)*Otzt^2 + coef9(4)
 Otzt^1;
toruseq1z = toruseq1z + coef10(1)*px1t^4 + coef10(2)*px1t^3 + coef10(3)*px1t^2 + coef10(4)
*px1t^1;
toruseq1z = toruseq1z + coef11(1)*py1t^4 + coef11(2)*py1t^3 + coef11(3)*py1t^2 + coef11(4)
*py1t^1;
toruseq1z = toruseq1z + coef12(1)*pz1t^4 + coef12(2)*pz1t^3 + coef12(3)*pz1t^2 + coef12(4)
*pz1t^1;
toruseq1z = toruseq1z + coef13(1)*Thtt^4 + coef13(2)*Thtt^3 + coef13(3)*Thtt^2 + coef13(4)
*Thtt^1;
toruseq1z = toruseq1z + coef14(1)*Thtnt^4 + coef14(2)*Thtnt^3 + coef14(3)*Thtnt^2 + coef14
(4)*Thtnt^1;
disp('finished computation of toruseq1z...');
fprintf(fid,'\n\ntoruseq1z = Sum of: \n');
for i1 = 1:4
  fprintf(fid,'%20.12f',coef6(i1));
  fprintf(fid,' Rtt^%1i',i1);
  fprintf(fid,'\n');
end
for i1 = 1:4
  fprintf(fid,'%20.12f',coef7(i1));
  fprintf(fid,' Otxt^%1i',i1);
  fprintf(fid,'\n');
end
for i1 = 1:4
  fprintf(fid,'%20.12f',coef8(i1));
  fprintf(fid,' Otyt^%1i',i1);
  fprintf(fid,'\n');
end
for i1 = 1:4
  fprintf(fid,'%20.12f',coef9(i1));
  fprintf(fid,' Otzt^%1i',i1);
  fprintf(fid,'\n');
end
for i1 = 1:4
  fprintf(fid,'%20.12f',coef10(i1));
  fprintf(fid,' px1t^%1i',i1);
  fprintf(fid,'\n');
end
for i1 = 1:4
  fprintf(fid,'%20.12f',coef11(i1));
  fprintf(fid,' py1t^%1i',i1);
  fprintf(fid,'\n');
end
for i1 = 1:4
  fprintf(fid,'%20.12f',coef12(i1));
  fprintf(fid,' pz1t^%1i',i1);
  fprintf(fid,'\n');
end
for i1 = 1:4
  fprintf(fid,'%20.12f',coef13(i1));
  fprintf(fid,' Thtt^%1i',i1);
  fprintf(fid,'\n');
end
for i1 = 1:4
  fprintf(fid,'%20.12f',coef14(i1));
  fprintf(fid,' Thtnt^%1i',i1);
  fprintf(fid,'\n');
end

fprintf(fid,'\n\nTest of torus1z');
Rtt = 5.0;
```

```
Otxt = 0.0;
Otyt = 0.0;
Otzt = 0.0;
pxlt = 0.0;
pylt = 0.0;
pzlt = 0.0;
Thtt = 0.0;
Thtnt = 0.0;
fprintf(fid,'\nRtt = %20.12f',Rtt);
fprintf(fid,'\nOtx = %20.12f',Otxt);
fprintf(fid,'\nOty = %20.12f',Otyt);
fprintf(fid,'\nOtz = %20.12f',Otzt);
fprintf(fid,'\npxlt = %20.12f',pxlt);
fprintf(fid,'\npylt = %20.12f',pylt);
fprintf(fid,'\npzlt = %20.12f',pzlt);
fprintf(fid,'\nThtt = %20.12f',Thtt);
fprintf(fid,'\nThtnt = %20.12f',Thtnt);
fprintf(fid,'\ntorus1z = %20.12f',eval(torus1z));
fprintf(fid,'\n');
fprintf(fid,'\n\nTest of torus1z');
Rtt = 5.0;
Otxt = 0.0;
Otyt = 0.0;
Otzt = 0.0;
pxlt = 10.0;
pylt = 0.0;
pzlt = 0.0;
Thtt = 0.0;
Thtnt = 0.0;
fprintf(fid,'\nRtt = %20.12f',Rtt);
fprintf(fid,'\nOtx = %20.12f',Otxt);
fprintf(fid,'\nOty = %20.12f',Otyt);
fprintf(fid,'\nOtz = %20.12f',Otzt);
fprintf(fid,'\npxlt = %20.12f',pxlt);
fprintf(fid,'\npylt = %20.12f',pylt);
fprintf(fid,'\npzlt = %20.12f',pzlt);
fprintf(fid,'\nThtt = %20.12f',Thtt);
fprintf(fid,'\nThtnt = %20.12f',Thtnt);
fprintf(fid,'\ntorus1z = %20.12f',eval(torus1z));
fprintf(fid,'\n');
fprintf(fid,'\n\nTest of torus1z');
Rtt = 5.0;
Otxt = 0.0;
Otyt = 0.0;
Otzt = 0.0;
pxlt = 0.0;
pylt = 0.0;
pzlt = 10.0;
Thtt = 0.0;
Thtnt = 0.0;
fprintf(fid,'\nRtt = %20.12f',Rtt);
fprintf(fid,'\nOtx = %20.12f',Otxt);
fprintf(fid,'\nOty = %20.12f',Otyt);
fprintf(fid,'\nOtz = %20.12f',Otzt);
fprintf(fid,'\npxlt = %20.12f',pxlt);
fprintf(fid,'\npylt = %20.12f',pylt);
fprintf(fid,'\npzlt = %20.12f',pzlt);
fprintf(fid,'\nThtt = %20.12f',Thtt);
fprintf(fid,'\nThtnt = %20.12f',Thtnt);
fprintf(fid,'\ntorus1z = %20.12f',eval(torus1z));
fprintf(fid,'\n');
fprintf(fid,'\n\nTest of torus1z');
Rtt = 5.0;
Otxt = 0.0;
Otyt = 0.0;
Otzt = 0.0;
```

```
px1t = -10.0;
py1t = 0.0;
pz1t = 0.0;
Thtt = 0.0;
Thtnt = 0.0;
fprintf(fid,'\nRtt = %20.12f',Rtt);
fprintf(fid,'\nOtx = %20.12f',Otxt);
fprintf(fid,'\nOty = %20.12f',Otyt);
fprintf(fid,'\nOtz = %20.12f',Otzt);
fprintf(fid,'\npx1t = %20.12f',px1t);
fprintf(fid,'\npy1t = %20.12f',py1t);
fprintf(fid,'\npz1t = %20.12f',pz1t);
fprintf(fid,'\nThtt = %20.12f',Thtt);
fprintf(fid,'\nThtnt = %20.12f',Thtnt);
fprintf(fid,'\ntorus1z = %20.12f',eval(torus1z));
fprintf(fid,'\n');
fprintf(fid,'\n\nTest of torus1z');
Rtt = 5.0;
Otxt = 0.0;
Otyt = 0.0;
Otzt = 0.0;
px1t = 0.0;
py1t = 0.0;
pz1t = -10.0;
Thtt = 0.0;
Thtnt = 0.0;
fprintf(fid,'\nRtt = %20.12f',Rtt);
fprintf(fid,'\nOtx = %20.12f',Otxt);
fprintf(fid,'\nOty = %20.12f',Otyt);
fprintf(fid,'\nOtz = %20.12f',Otzt);
fprintf(fid,'\npx1t = %20.12f',px1t);
fprintf(fid,'\npy1t = %20.12f',py1t);
fprintf(fid,'\npz1t = %20.12f',pz1t);
fprintf(fid,'\nThtt = %20.12f',Thtt);
fprintf(fid,'\nThtnt = %20.12f',Thtnt);
fprintf(fid,'\ntorus1z = %20.12f',eval(torus1z));
fprintf(fid,'\n');

%;
%; compute the multi-torus equation
%;    - ...f(x,y,z,r1,r2,th1,th2,r3,thm1)
%;    - cumulative equation generated with a for loop
%;

px1t = px1;
py1t = py1;
pz1t = pz1;
th1t = th1;
th2t = th2;


syms Rmt Thmt nT tmpmTx tmpmTy tmpmTz coef15 coef16;
Otxt = Rmt*cos(Thmt);
Otyt = Rmt*sin(Thmt);
Otzt = 0.0;
Thtt = 0.0;
Thtnt = 0.0;
nT = 16;
Rtt = 20*r1;

tmpmTx = 0;
for i1 = 1:nT
   Thmt = i1*2*3.14159/nT;
   tmpmTx = tmpmTx + toruseq1x;
end
```

```
Rmt = 1000*r1;
a1 = [Rmt^4 Rmt^3 Rmt^2 Rmt^1;];
b1 = [eval(tmpmTx);];
Rmt = 2000*r1;
a1 = [a1; Rmt^4 Rmt^3 Rmt^2 Rmt^1;];
b1 = [b1; eval(tmpmTx);];
Rmt = 10000*r1;
a1 = [a1; Rmt^4 Rmt^3 Rmt^2 Rmt^1;];
b1 = [b1; eval(tmpmTx);];
Rmt = 160000*r1;
a1 = [a1; Rmt^4 Rmt^3 Rmt^2 Rmt^1;];
b1 = [b1; eval(tmpmTx);];
%;
%; These are the coeff. for the multi-torus eq. Rmt = variable
%;
coef15 = pinv(a1)*b1;
disp('coef15...');

Rmt = 1200*r1;
Rt = 20*r1;
a1 = [Rt^4 Rt^3 Rt^2 Rt^1;];
b1 = [eval(tmpmTx) - coef15(1)*Rmt^4 - coef15(2)*Rmt^3 - coef15(3)*Rmt^2 coef15(4)*Rmt^
1;];
Rt = 40*r1;
a1 = [a1; Rt^4 Rt^3 Rt^2 Rt^1;];
b1 = [b1; eval(tmpmTx) - coef15(1)*Rmt^4 - coef15(2)*Rmt^3 - coef15(3)*Rmt^2 coef15(4)
*Rmt^1;];
Rt = 80*r1;
a1 = [a1; Rt^4 Rt^3 Rt^2 Rt^1;];
b1 = [b1; eval(tmpmTx) - coef15(1)*Rmt^4 - coef15(2)*Rmt^3 - coef15(3)*Rmt^2 coef15(4)
*Rmt^1;];
Rt = 120*r1;
a1 = [a1; Rt^4 Rt^3 Rt^2 Rt^1;];
b1 = [b1; eval(tmpmTx) - coef15(1)*Rmt^4 - coef15(2)*Rmt^3 - coef15(3)*Rmt^2 coef15(4)
*Rmt^1;];
%;
%; These are the coeff. for the multi-torus eq. Rmt = 1200, Rt = variable
%;
coef16 = pinv(a1)*b1;
disp('coef16...');


%;
%; Here is the final multi-torus equation (fox x here)
%;
syms multitorus1x multitorus1y multitorus1z;
coef15 = eval(coef15);
coef16 = eval(coef16);
multitorus1x = coef15(1)*Rmt^4 + coef15(2)*Rmt^3 + coef15(3)*Rmt^2 + coef15(4)*Rmt^1;
multitorus1x = multitorus1x + coef16(1)*Rt^4 + coef16(2)*Rt^3 + coef16(3)*Rt^2 + coef16(4)
*Rt^1;
disp('finished computation of multitorus1x...');
fprintf(fid,'\n\nmultitorus1x = Sum of: \n');
for i1 = 1:4
  fprintf(fid,'%20.12f',coef15(i1));
  fprintf(fid,' Rmt^%1i',i1);
  fprintf(fid,'\n');
end
for i1 = 1:4
  fprintf(fid,'%20.12f',coef16(i1));
  fprintf(fid,' Rt^%1i',i1);
  fprintf(fid,'\n');
end
fprintf(fid,'\n\nTest of multitorus1x');
Rt = 20;
Rmt = 100;
```

```
fprintf(fid,'\nRt = %20.12f',Rt);
fprintf(fid,'\nRmt = %20.12f',Rmt);
fprintf(fid,'\nmultitorus1x = %20.12f',multitorus1x);
fprintf(fid,'\n');


Otxt = Rmt*cos(Thmt);
Otyt = Rmt*sin(Thmt);
Otzt = 0.0;
Thtt = 0.0;
nT = 16;

tmpmTy = 0;
for i1 = 1:nT
  Thmt = i1*2*3.14159/nT;
  tmpmTy = tmpmTy + toruseq1y;
end

Rmt = 1000*r1;
a1 = [Rmt^4 Rmt^3 Rmt^2 Rmt^1;];
b1 = [eval(tmpmTy);];
Rmt = 2000*r1;
a1 = [a1; Rmt^4 Rmt^3 Rmt^2 Rmt^1;];
b1 = [b1; eval(tmpmTy);];
Rmt = 10000*r1;
a1 = [a1; Rmt^4 Rmt^3 Rmt^2 Rmt^1;];
b1 = [b1; eval(tmpmTy);];
Rmt = 160000*r1;
a1 = [a1; Rmt^4 Rmt^3 Rmt^2 Rmt^1;];
b1 = [b1; eval(tmpmTy);];

%;
%; These are the coeff. for the multi-torus eq. Rmt = variable
%;
coef15 = pinv(a1)*b1;
disp('coef15...');

Rmt = 1200*r1;
Rt = 20*r1;
a1 = [Rt^4 Rt^3 Rt^2 Rt^1;];
b1 = [eval(tmpmTy) - coef15(1)*Rmt^4 - coef15(2)*Rmt^3 - coef15(3)*Rmt^2 coef15(4)*Rmt^
1;];
Rt = 40*r1;
a1 = [a1; Rt^4 Rt^3 Rt^2 Rt^1;];
b1 = [b1; eval(tmpmTy) - coef15(1)*Rmt^4 - coef15(2)*Rmt^3 - coef15(3)*Rmt^2 coef15(4)
*Rmt^1;];
Rt = 80*r1;
a1 = [a1; Rt^4 Rt^3 Rt^2 Rt^1;];
b1 = [b1; eval(tmpmTy) - coef15(1)*Rmt^4 - coef15(2)*Rmt^3 - coef15(3)*Rmt^2 coef15(4)
*Rmt^1;];
Rt = 120*r1;
a1 = [a1; Rt^4 Rt^3 Rt^2 Rt^1;];
b1 = [b1; eval(tmpmTy) - coef15(1)*Rmt^4 - coef15(2)*Rmt^3 - coef15(3)*Rmt^2 coef15(4)
*Rmt^1;];
%;
%; These are the coeff. for the multi-torus eq. Rmt = 1200, Rt = variable
%;
coef16 = pinv(a1)*b1;
disp('coef16...');


%;
%; Here is the final multi-torus equation
%;
syms Rt Rmt;
multitorus1y = coef15(1)*Rmt^4 + coef15(2)*Rmt^3 + coef15(3)*Rmt^2 + coef15(4)*Rmt^1;
```

```
multitorusly = multitorusly + coef16(1)*Rt^4 + coef16(2)*Rt^3 + coef16(3)*Rt^2 + coef16(4)
*Rt^1;
disp('finished computation of multitorusly...');
fprintf(fid,'\n\nmultitorusly = Sum of: \n');
 or i1 = 1:4
   fprintf(fid,'%20.12f',coef15(i1));
   fprintf(fid,' Rmt^%1i',i1);
   fprintf(fid,'\n');
end
for i1 = 1:4
   fprintf(fid,'%20.12f',coef16(i1));
   fprintf(fid,' Rt^%1i',i1);
   fprintf(fid,'\n');
end
fprintf(fid,'\n\nTest of multitorusly');
Rt = 20;
Rmt = 100;
fprintf(fid,'\nRt = %20.12f',Rt);
fprintf(fid,'\nRmt = %20.12f',Rmt);
fprintf(fid,'\nmultitorusly = %20.12f',eval(multitorusly));
fprintf(fid,'\n');


Otx = Rmt*cos(Thmt);
Oty = Rmt*sin(Thmt);
Otz = 0.0;
nT = 16;

tmpmTz = 0;
for i1 = 1:nT
   Thmt = i1*2*3.14159/nT;
   tmpmTz = tmpmTz + toruseqlz;
end

Rmt = 1000*r1;
a1 = [Rmt^4 Rmt^3 Rmt^2 Rmt^1;];
b1 = [eval(tmpmTz);];
Rmt = 2000*r1;
a1 = [a1; Rmt^4 Rmt^3 Rmt^2 Rmt^1;];
b1 = [b1; eval(tmpmTz);];
Rmt = 10000*r1;
a1 = [a1; Rmt^4 Rmt^3 Rmt^2 Rmt^1;];
b1 = [b1; eval(tmpmTz);];
Rmt = 160000*r1;
a1 = [a1; Rmt^4 Rmt^3 Rmt^2 Rmt^1;];
b1 = [b1; eval(tmpmTz);];

%;
%; These are the coeff. for the multi-torus eq. Rmt = variable
%;
coef15 = pinv(a1)*b1;
disp('coef15...');

Rmt = 1200*r1;
Rt = 20*r1;
a1 = [Rt^4 Rt^3 Rt^2 Rt^1;];
b1 = [eval(tmpmTz) - coef15(1)*Rmt^4 - coef15(2)*Rmt^3 - coef15(3)*Rmt^2 coef15(4)*Rmt^
1;];
Rt = 40*r1;
a1 = [a1; Rt^4 Rt^3 Rt^2 Rt^1;];
b1 = [b1; eval(tmpmTz) - coef15(1)*Rmt^4 - coef15(2)*Rmt^3 - coef15(3)*Rmt^2 coef15(4)
Rmt^1;];
Rt = 80*r1;
a1 = [a1; Rt^4 Rt^3 Rt^2 Rt^1;];
b1 = [b1; eval(tmpmTz) - coef15(1)*Rmt^4 - coef15(2)*Rmt^3 - coef15(3)*Rmt^2 coef15(4)
*Rmt^1;];
```

```
Rt = 120*r1;
a1 = [a1; Rt^4 Rt^3 Rt^2 Rt^1;];
b1 = [b1; eval(tmpmTz) - coef15(1)*Rmt^4 - coef15(2)*Rmt^3 - coef15(3)*Rmt^2 coef15(4)
*Rmt^1;];
;
%; These are the coeff. for the multi-torus eq. Rmt = 1200, Rt = variable
%;
coef16 = pinv(a1)*b1;
disp('coef16...');


%;
%; Here is the final multi-torus equation
%;

multitorus1z = coef15(1)*Rmt^4 + coef15(2)*Rmt^3 + coef15(3)*Rmt^2 + coef15(4)*Rmt^1;
multitorus1z = multitorus1z + coef16(1)*Rt^4 + coef16(2)*Rt^3 + coef16(3)*Rt^2 + coef16(4)
*Rt^1;
disp('finished computation of multitorus1z...');
fprintf(fid,'\n\nmultitorus1z = Sum of: \n');
for i1 = 1:4
   fprintf(fid,'%20.12f',coef15(i1));
   fprintf(fid,' Rmt^%1i',i1);
   fprintf(fid,'\n');
end
for i1 = 1:4
   fprintf(fid,'%20.12f',coef16(i1));
   fprintf(fid,' Rt^%1i',i1);
   fprintf(fid,'\n');
end
fprintf(fid,'\n\nTest of multitorus1z');
Rt = 20;
Rmt = 100;
fprintf(fid,'\nRt = %20.12f',Rt);
fprintf(fid,'\nRmt = %20.12f',Rmt);
fprintf(fid,'\nmultitorus1z = %20.12f',multitorus1z);
fprintf(fid,'\n');


%;
%; compute the plasma-torus equation
%;    - plasma toroid equation is f(pr1,pth1,pth2,pr2)
%;    - inner ring x = r*cos(pth1) y = r*sin(pth1)
%;    - outer branch is 1st toroid equation
%;    - vector inward is from outer branch point directed back to ring
%;    - final toroid equation is projection of Bx,By,Bz onto vector in
%;    - cos thbp = Bx*vix + circle1y*viy + circle1z*viz/ || B || || vi ||
%;    - proj. = || B || cos thbp
%;    - ...the multi-torus crossed with the plasma-torus
syms plrad plrad2 pth1 plx1 ply1 plz1 proj1 proj2 proj3 proj4 ptplx1 ptply1 ptplz1;
syms vec1x vec1y vec1z;
Otxt = Otx;
Otyt = Oty;
Otzt = Otz;
Thtt = Tht;
Thtnt = Thtn;


pth1 = 3.14159/2;
plx1 = plrad*cos(pth1);
ply1 = plrad*sin(pth1);
plz1 = 0.0;
pth2 = pth1/(2*3.14159*plrad);
proj1 = plrad2*cos(pth2);
proj2 = (plrad + proj1)*cos(pth1);
proj3 = plrad2*sin(pth2);
```

```matlab
proj4 = proj1*sin(pth1);
ptplx1 = proj2;
ptply1 = proj4;
ptplz1 = proj3;
vec1x = ptplx1 - plx1;
vec1y = ptply1 - ply1;
vec1z = ptplz1 - plz1;
plrad = Rmt;
plrad2 = Rtt;


syms disB disVec thbp projMt;

disB = sqrt(multitorus1x^2 + multitorus1y^2 + multitorus1z^2);
disVec = sqrt(vec1x^2 + vec1y^2 + vec1z^2);
thbp = acos((multitorus1x*vec1x + multitorus1y*vec1y + multitorus1z*vec1z)/(disB*disVec));
projMt = disB*cos(thbp);
disp('finished computation of projMt...');
fprintf(fid,'\n\ndisB = ');
fprintf(fid,'\ndisB = %20.12f',eval(disB));
fprintf(fid,'\ndisVec = ');
fprintf(fid,char(disVec));
fprintf(fid,'\nthbp = ');
fprintf(fid,char(thbp));
fprintf(fid,'\nprojMt = ');
fprintf(fid,char(projMt));
fprintf(fid,'\n');


%;
%; compute the minimum of the plasma-torus equation
%;  - compute the derivative of the plasma-torus equation
%;  - ...derivative is found with matlab
%;  - set the minimum to the necessary pressure and temperature for
%;  - ...fusion
%;  - compute all of the roots of the derivative
%;  - ...roots are found with matlab
%;  - find the root that produces the minimum
%;  - ...by going down the list
%;
%; f(Rt,Rmt,ptplx1,ptply1,ptplz1) matrix (4 terms per variable)
%; find first derivative
%; find roots of first derivative
syms coef17 coef18 coef19 coef20 coef21;
Otxt = Otx;
Otyt = Oty;
Otzt = Otz;


Rt = 20;

Rtt = Rt;


a1 = [Rt^4 Rt^3 Rt^2 Rt^1;];
b1 = [eval(projMt);];
Rt = 40;
a1 = [a1; Rt^4 Rt^3 Rt^2 Rt^1;];
b1 = [b1; eval(projMt);];
Rt = 80;
a1 = [a1; Rt^4 Rt^3 Rt^2 Rt^1;];
b1 = [b1; eval(projMt);];
Rt = 160;
a1 = [a1; Rt^4 Rt^3 Rt^2 Rt^1;];
b1 = [b1; eval(projMt);];
coef17 = pinv(a1)*b1;
```

```
disp('coef17...');

Rt = 20;
Rmt = 100;
a1 = [Rmt^4 Rmt^3 Rmt^2 Rmt^1;];
b1 = [eval(projMt) - coef17(1)*Rt^4 - coef17(2)*Rt^3 - coef17(3)*Rt^2 - coef17(4)*Rt^1;];
Rmt = 200;
a1 = [a1; Rmt^4 Rmt^3 Rmt^2 Rmt^1;];
b1 = [b1; eval(projMt) - coef17(1)*Rt^4 - coef17(2)*Rt^3 - coef17(3)*Rt^2 - coef17(4)*Rt^
1;];
Rmt = 400;
a1 = [a1; Rmt^4 Rmt^3 Rmt^2 Rmt^1;];
b1 = [b1; eval(projMt) - coef17(1)*Rt^4 - coef17(2)*Rt^3 - coef17(3)*Rt^2 - coef17(4)*Rt^
1;];
Rmt = 800;
a1 = [a1; Rmt^4 Rmt^3 Rmt^2 Rmt^1;];
b1 = [b1; eval(projMt) - coef17(1)*Rt^4 - coef17(2)*Rt^3 - coef17(3)*Rt^2 - coef17(4)*Rt^
1;];
coef18 = pinv(a1)*b1;
disp('coef18...');


syms plasmatorus1 plasmatorusdiff1;
syms plasmatorusdiff2Rt plasmatorusdiff2Rmt;
syms plasmatorusdiff3Rt plasmatorusdiff3Rmt;
syms size1 size2 ii1 ii2 curmin testmin minRt minRmt;

plasmatorus1 = coef17(1)*Rt^4 + coef17(2)*Rt^3 + coef17(3)*Rt^2 + coef17(4)*Rt^1;
plasmatorus1 = plasmatorus1 + coef18(1)*Rmt^4 + coef18(2)*Rmt^3 + coef18(3)*Rmt^2 + coef18
(4)*Rmt^1;
disp('finished computation of plasmatorus1...');
fprintf(fid,'\n\nplasmatorus1 = Sum of: \n');
for i1 = 1:4
   fprintf(fid,'%20.12f',coef17(i1));
   fprintf(fid,' Rt^%1i',i1);
   fprintf(fid,'\n');
end
for i1 = 1:4
   fprintf(fid,'%20.12f',coef18(i1));
   fprintf(fid,' Rmt^%1i',i1);
   fprintf(fid,'\n');
end




plasmatorusdiff2Rt = [coef17(1)*4 coef17(2)*3 coef17(3)*2 coef17(4)*1];
plasmatorusdiff2Rmt = [coef18(1)*4 coef18(2)*3 coef18(3)*2 coef18(4)*1];

plasmatorusdiff3Rt = roots(plasmatorusdiff2Rt);
plasmatorusdiff3Rmt = roots(plasmatorusdiff2Rmt);
fprintf(fid,'\n\nplasmatorusdiff3 = Sum of: \n');
for i1 = 1:3
   fprintf(fid,'%20.12f',plasmatorusdiff3Rt(i1));
   fprintf(fid,' plasmatorusdiff3Rt^%1i',i1);
   fprintf(fid,'\n');
end
for i1 = 1:3
   fprintf(fid,'%20.12f',plasmatorusdiff3Rmt(i1));
   fprintf(fid,' plasmatorusdiff3Rmt^%1i',i1);
   fprintf(fid,'\n');
end


size1 = size(plasmatorusdiff3Rt,1);
```

```
size2 = size(plasmatorusdiff3Rmt,1);

syms plamat1 Rtx Rtmx ptplx1x ptply1x ptplz1x;
plasmat1 = coef17(1)*Rtx^4 + coef17(2)*Rtx^3 + coef17(3)*Rtx^2 + coef17(4)*Rtx^1;
 lasmat1 = plasmat1 + coef18(1)*Rtmx^4 + coef18(2)*Rtmx^3 + coef18(3)*Rtmx^2 + coef18(4)
 Rtmx^1;


curmin = 9999999;
for ii1 = 1:size1
  for ii2 = 1:size2
    Rtx = plasmatorusdiff3Rt(ii1);
    Rtmx = plasmatorusdiff3Rmt(ii2);
    testmin = eval(plasmat1);
    if or((testmin < curmin),(curmin == 9999999))
      curmin = testmin;
      minRt = Rtx;
      minRtm = Rtmx;
    end
  end
end
disp('finished computation of minimum of plasmatorus eq...');
fprintf(fid,'\n\nMinimum of Plasmatorus Eq Occurs At:');
fprintf(fid,'\nminRt = %20.12f',minRt);
fprintf(fid,'\nminRtm = %20.12f',minRtm);
fprintf(fid,'\n');

syms Rtq Rtmq plasmatorusm;
Rt = minRt;
Rmt = minRtm;
plasmatorusm = coef17(1)*Rtq^4 + coef17(2)*Rtq^3 + coef17(3)*Rtq^2 + coef17(4)*Rtq^1;
plasmatorusm = plasmatorusm + coef18(1)*Rtmq^4 + coef18(2)*Rtmq^3 + coef18(3)*Rtmq^2 +
coef18(4)*Rtmq^1;
disp('finished computation of polynomial eq. of min of plasmatorus eq...');
fprintf(fid,'\n\nplasmatorusm = Sum of: \n');
for i1 = 1:4
  fprintf(fid,'%20.12f',coef17(i1));
  fprintf(fid,' Rt^%1i',i1);
  fprintf(fid,'\n');
end
for i1 = 1:4
  fprintf(fid,'%20.12f',coef18(i1));
  fprintf(fid,' Rmt^%1i',i1);
  fprintf(fid,'\n');
end




%;
%; general equation of surface of a torus with radiuses Rt and Rtm
%;
syms Surface1 Rtmm Rtmmm;
Surface1 = 4*3.14159*3.14159*Rtmm*Rtmmm;

syms plasmatm Rtqq Rtmqq ptplx1qq ptply1qq ptplz1qq;

plasmatm = coef17(1)*Rtqq^4 + coef17(2)*Rtqq^3 + coef17(3)*Rtqq^2 + coef17(4)*Rtqq^1;
plasmatm = plasmatm + coef18(1)*Rtmqq^4 + coef18(2)*Rtmqq^3 + coef18(3)*Rtmqq^2 + coef18
(4)*Rtmqq^1;


%;
%; compute the current equation for ring sizes
%;  - polynomial I (10) R1 (10) R2 (10) R3 (10) N1 (10) N2 (10)
%;
```

```matlab
%; compute a table of current, ring sizes, number of rings, etc.
%;  - for current (1 Amp to 100 Amp) (wait on this)
%;  - ring size 1 (1 to 5 meters)
%;  - ring size 2 (10 to 20 meters)
%;  - ring size 3 (40 to 80 meters)
%;  - # of rings 1 (10 to 20)
%;  - # of rings 2 (10 to 20)
%;  - # of rings 3 (10 to 20)
%;
%; some constants:
%; mass of electron = 9.110 * 10^-31 kg
%; charge of electron = 1.602192 * 10^-19 C
%; solenoid constant (u0) = 4*pi*10^-7 T A^-1
%; solenoid equation: B = u0 * n * I
%; Gas constant = 8.314 J mol^-1 K^-1
%; Avogadro's # = 6.022 * 10^23 molecules/mole
%;
syms melec qelec solu0 gask avogad speedc vor;
melec = 9.110*10^(-31);
qelec = 1.602192*10^(-19);
solu0 = 4*3.14159*10^(-7);
gask = 8.314;
avogad = 6.022*10^(23);
speedc = 2.9979*10^(8);
vor = 100/gask;
syms rsize1 rsize2 rsize3 nrings1 nrings2 minB fperA cur1 cur2;
syms Efmt Ffmt vfmt nfmt Bpar Fpar Vpar Energy1 Pressure1 Temperature1;
%; compute and print:
                %; Efmt = speedc*plasmatm;
                %; Ffmt = qelec*Efmt;
                %; vfmt = (Ffmt/melec)*60;
                %; nfmt = 2*3.14159/0.05;
                %; Bpar = nfmt*cur2*solu0;
                %; Fpar = qelec*vfmt*Bpar;
                %; vpar = (Fpar/1)*1;
                %; Energy1 = (1/2)*1*vpar^2/vor;
                %; Temperature1 = gask*Energy1;
                %; Pressure1 = vor*gask*Temperature1/(4*3.14159*3.14159*rsize3*rsize3);
fprintf(fid,'\n\nTable of Minimum B Field Due to Various Radius Sizes and Number of
Toruses');
fprintf(fid,'\n');
for rsize1 = 1:2
  for rsize2 = 10:10
    for rsize3 = 40:40
      for nrings1 = 10:11
        for nrings2 = 10:11
          for nrings3 = 10:10
            for cur1 = 1:1
              for cur2 = 1:1
                r1 = rsize1;
                Rtqq = rsize2;
                Rtmqq = rsize3;
                nr = nrings1;
                nT = nrings2;
                Rtmm = Rtmqq;
                Rtmm = rsize1;
                Rtmmm = rsize2;
                minB = eval(plasmatm);
                fperA = minB*eval(Surface1);
                Efmt = speedc*plasmatm;
                Ffmt = qelec*Efmt;
                vfmt = (Ffmt/melec)*60;
                nfmt = 2*3.14159/0.05;
                Bpar = nfmt*cur2*solu0;
                Fpar = qelec*vfmt*Bpar;
                vpar = (Fpar/1)*1;
```

```matlab
                    Energy1 = (1/2)*1*vpar^2/vor;
                    Temperature1 = gask*Energy1;
                    Pressure1 = vor*gask*Temperature1/(4*3.14159*3.14159*rsize3*rsize3);
```

%;
%;   required fperA is a constant from textbook
%;

```matlab
                    disp('inner loop...');
                    rsize1
                    rsize2
                    rsize3
                    nrings1
                    nrings2
                    fprintf(fid,'\n');
                    fprintf(fid,'Ring Size 1 = ');
                    fprintf(fid,'%20.12f',rsize1);
                    fprintf(fid,'\n');
                    fprintf(fid,'Ring Size 2 = ');
                    fprintf(fid,'%20.12f',rsize2);
                    fprintf(fid,'\n');
                    fprintf(fid,'Ring Size 3 = ');
                    fprintf(fid,'%20.12f',rsize3);
                    fprintf(fid,'\n');
                    fprintf(fid,'# of Rings 1 = ');
                    fprintf(fid,'%4i',nrings1);
                    fprintf(fid,'\n');
                    fprintf(fid,'# of Rings 2 = ');
                    fprintf(fid,'%4i',nrings2);
                    fprintf(fid,'\n');
                    fprintf(fid,'minB = ');
                    fprintf(fid,'%20.12f',minB);
                    fprintf(fid,'\n');
                    fprintf(fid,'fperA = ');
                    fprintf(fid,'%20.12f',fperA);
                    fprintf(fid,'\n');
                    fprintf(fid,'\n');
                    fprintf(fid,'cur1 = ');
                    fprintf(fid,'%20.12f',cur1);
                    fprintf(fid,'\n');
                    fprintf(fid,'cur2 = ');
                    fprintf(fid,'%20.12f',cur2);
                    fprintf(fid,'\n');
                    fprintf(fid,'Temperature1 = ');
                    fprintf(fid,'%20.12f',eval(Temperature1));
                    fprintf(fid,'\n');
                    fprintf(fid,'Pressure1 = ');
                    fprintf(fid,'%20.12f',eval(Pressure1));
                    fprintf(fid,'\n');
```

%;
%;   print both of them for comparison
%;

```matlab
                end
            end
            end
          end
        end
      end
    end
end
disp('finished program.');
st = fclose(fid);
```